Remedial Investigation/Feasibility Study of the Soldier Creek/IWTP Groundwater Operable Unit at Tinker Air Force Base

Health & Safety Plan

Final

Prepared for

Oklahoma City Air Logistics Center
Tinker Air Force Base, Oklahoma

Prepared by

Engineering-Science, Inc.
Austin, Texas

May 1994

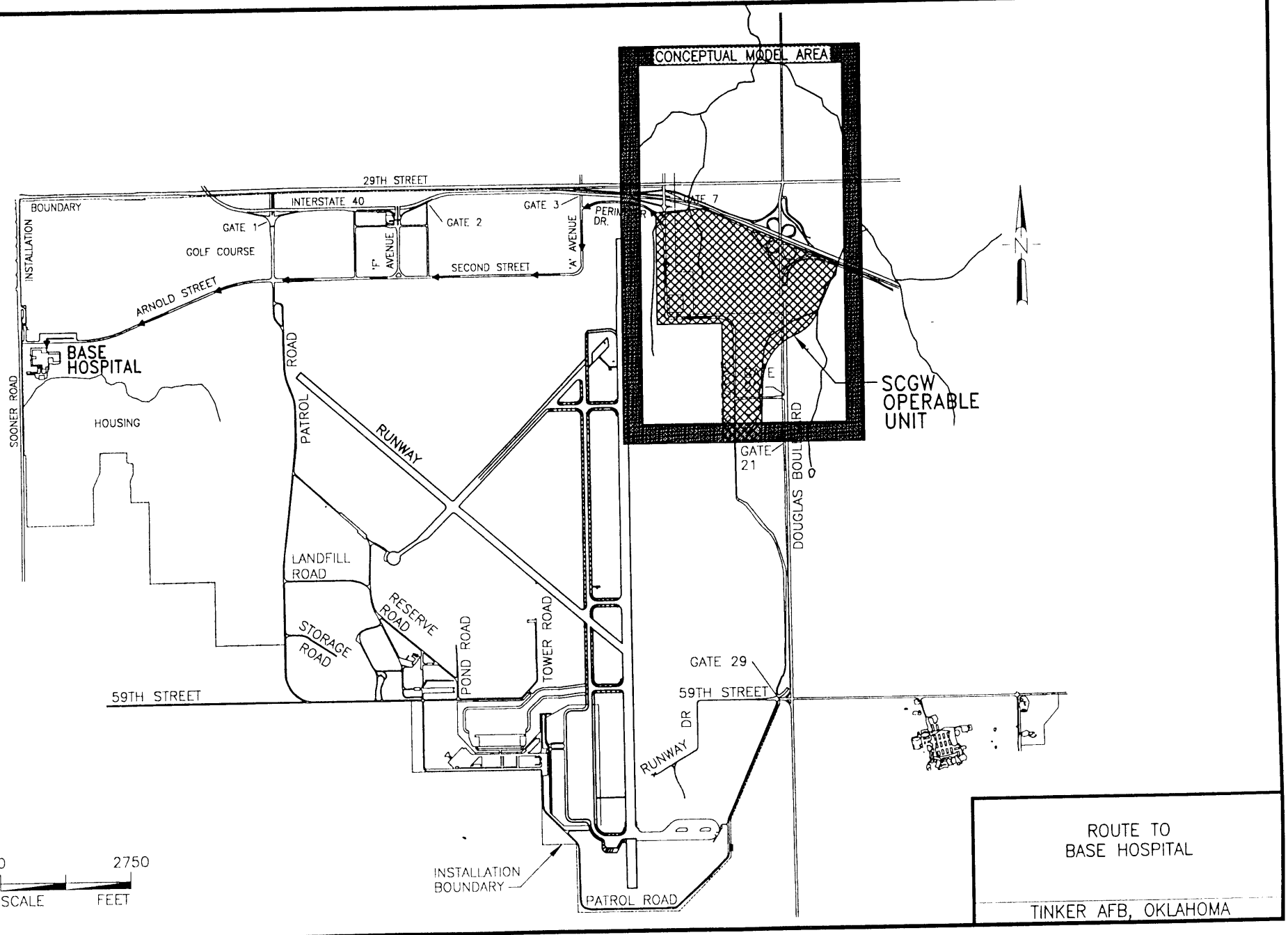
USAF Contract Number F34650-93-D-0106
Delivery Order Number 5001

	Name	Date
Project manager:	_____	_____
Office health and safety manager:	_____	_____
Site health and safety officer:	_____	_____

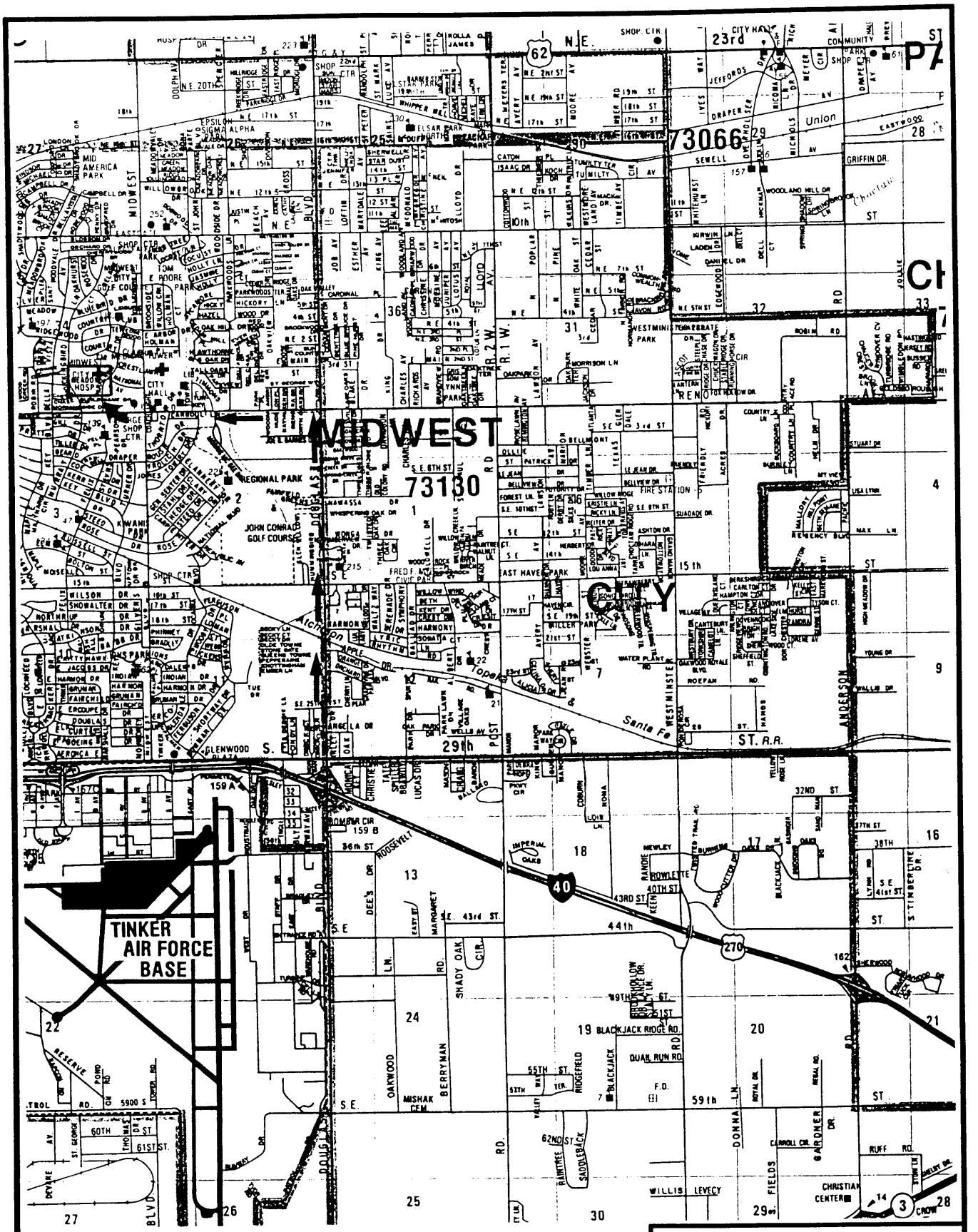
EMERGENCY INFORMATION
TINKER AIR FORCE BASE, OKLAHOMA

Organization	Telephone Number
Tinker AFB Emergency Number	117
Fire Department	734-7964
Base Hospital	734-8249
Ambulance	734-7964
Midwest City Regional Hospital	737-4411
Poison Control Center	800/492-2414
National Response Center	800/424-8802
ES Contract Physician	512/459-1111
ES Office Health and Safety Manager - Randy Palachek	512/719-6000
ES Site Health & Safety Officer - Marc Harder	512/719-6000
ES Project Manager - John Yu	512/719-6000
Tinker AFB Project Manager - John Schroeder	736-2941
Tinker AFB Contracting Officer - Gordon Mohon	739-3367

Note: When dialing from an on-base phone, it is not necessary to dial '73' of on-base phone numbers.



SCOBGW 5/25/94



ROUTE TO
MIDWEST CITY
HOSPITAL

TINKER AFB, OKLAHOMA

Action Levels

Level B Contaminant	Level
Benzene	> 1 ppm
Chromium	$\geq$ 250 mg/m^3
Dichloroethene	$\geq$ 1,000 ppm and < 4,000 ppm
Chlorobenzene	$\geq$ 500 ppm and $\leq$ 2,400 ppm
Vinyl Chloride	$\geq$ 1 ppm
1,2-Dichlorobenzene	$\geq$ 1,000 ppm
Tetrachloroethene	$\geq$ 25 ppm and $\leq$ 500 ppm
Trichloroethene	$\geq$ 50 ppm and $\leq$ 1,000 ppm

Level C Contaminant	Level
Chromium	> 0.5 mg/m^3 and < 250 mg/m^3
Dichloroethene	> 200 ppm and < 1,000 ppm
Chlorobenzene	> 10 ppm and < 500 ppm
1,2-Dichlorobenzene	> 50 ppm and < 1,000 ppm
Trichloroethene	< 50 ppm
Organic Vapors	< 5 ppm with < 1 ppm Vinyl Chloride < 10 ppm with < 1 ppm Vinyl Chloride and < 5 ppm Phenol

Level D Contaminant	Level
Benzene	< 1 ppm
Chlorobenzene	< 10 ppm
Chromium	< 0.5 mg/m^3
Dichloroethene	< 200 ppm
Ethyl benzene	<100 ppm
Vinyl Chloride	< 1 ppm
1,2-Dichlorobenzene	< 50 ppm
Tetrachloroethene	< 25 ppm
Toluene	<50 ppm
Trichloroethene	< 50 ppm
Xylenes	<100 ppm

Explosive Vapors and Oxygen Deficient Atmospheres Contaminant	Level to Stop Work
Combustible Vapors	> 10% LEL
Oxygen	< 19.5% or > 23.5%

ACRONYMS AND ABBREVIATIONS

ACGIH	American Conference of Governmental Industrial Hygienists
AFB	Air Force Base
APR	Air-purifying respirator
ASTM	American Society for Testing and Materials
CFR	Code of Federal Regulations
CNS	Central nervous system
CPR	Cardiopulmonary resuscitation
CRZ	Contamination reduction zone
dB	Decibel
DCE	Dichloroethene
ES	Engineering-Science, Inc.
eV	Electron volt
EZ	Exclusion zone
FID	Flame ionization detector
FS	Feasibility Study
H&S	Health and safety
IDLH	Immediately dangerous to life and health
LEL	Lower explosive limit
MCL	Maximum contaminant level
μS/cm	Micro Seimens per centimeter
MCL	Maximum contaminant level
mg/kg	Milligrams per kilogram
mg/L	Milligrams per liter
mg/m^3	Milligrams per cubic meter
mph	Miles per hour
MSDS	Material safety data sheet
MSHA	Mine safety and health administration
MSL	Mean sea level
MW	Monitoring well
NIOSH	National Institute of Occupational Safety and Health
NPL	National Priorities List
OSHA	Occupational Safety and Health Administration
OVA	Organic vapor analyzer
O_2	Oxygen
PEL	Permissible exposure limit
PFD	Personal flotation device
PID	Photoionization detector
PPE	Personal protective equipment
ppm	Parts per million

RI	Remedial investigation
SCBA	Self-contained breathing apparatus
SCGW	Soldier Creek/IWTP Groundwater Operable Unit
SHSO	Site health and safety officer
SZ	Support zone
TCE	Trichloroethene
TCL	Target compound list
TLV	Threshold limit values
TWA	Time-weighted average
USACE	U.S. Army Corps of Engineers
°C	Degrees Celsius
°F	Degrees Fahrenheit

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FIGURES

TABLES

Plan Acceptance Form

I, _____, have read the Health and Safety Plan for the remedial investigation and associated activities at Tinker Air Force Base and agree to abide by the rules and guidelines contained therein.

Signature	Date	Signature	Date
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SECTION 1

PURPOSE AND POLICY

The purpose of this health and safety (H&S) plan is to establish protection standards and mandatory safety practices and procedures for Engineering-Science, Inc. (ES) personnel employed in the project field activities at Tinker Air Force Base (AFB), Oklahoma. The plan also provides responses for contingencies that may arise during field investigations. The provisions of this plan are mandatory for all on-site activities. All ES personnel on the site will abide by this plan unless otherwise specified through formal addenda. All ES personnel who engage in field investigation activities for this project will be familiar with this plan and comply with its requirements. The development, implementation, and enforcement of the H&S plan is the responsibility of ES. Subcontractors will be required to submit their own H&S Plan which conforms to the requirements of this plan, at a minimum. The contents of this plan may be revised or modified at any time based on the receipt of new information as the field work progresses.

The expertise of personnel from various disciplines will be employed to assist in conducting the field investigation safely. This plan complies with requirements of the Occupational Safety and Health Administration (OSHA) Title 29, Code of Federal Regulations Parts 1910 and 1926 (29 CFR 1910 and 1926) and other applicable health and safety regulations.

A site description and scope of work summary for the project are provided in Section 2. Section 3 presents the project team organization, personnel responsibilities, and lines of authority. Site-specific training and medical monitoring requirements are contained in Section 4. Section 5 presents a safety and health risk analysis. Section 6 contains the site emergency response plan and list of emergency contacts. Site-specific requirements for levels of protection are included in Section 7. Air monitoring procedures, equipment, and instrument calibration are provided in Section 8. Site control measures, including designation of site work zones, are contained in Section 9, and Section 10 provides detailed site-specific decontamination procedures.

All field team members are responsible for reading and complying with the project H&S plan. No employee shall perform a project activity that he or she believes may endanger his or her health and safety or the health and safety of others.

SECTION 2

SITE DESCRIPTION AND SCOPE OF WORK

2.1 BACKGROUND

Site:	Tinker Air Force Base
Contracting Officer:	Gordon Mohon
Telephone Number:	405/739-3367
Technical Point of Contact:	John Schroeder, P.E.
Site Telephone Number:	405/736-2941
Proposed Dates of Work:	September 1, 1993, to September 30, 1995
Overall Hazards	Low

2.2 SITE HISTORY AND DESCRIPTION

Tinker AFB is located in southeast Oklahoma near Oklahoma City. Average temperature ranges from 60 to 62 degrees Fahrenheit (°F) with extremes ranging from -17 to 113°F. Rainfall averages 33 inches per year, and snow accumulates from November to March for an average of 9 inches. Winds at Tinker AFB are variable, prevailing from the southeast and averaging 14 miles per hour with the possibility of gusts up to 87 miles per hour. Annual percent calm is one percent.

The field investigation will take place northeast of Building 3001 on the Soldier Creek/ITWP Groundwater (SCGW) Operable Unit of the Building 3001 NPL site.

The majority of the work covered by this plan will take place off-base, on public and private lands. It is anticipated that most of the field investigations will be carried out under low to no contamination levels. However, this plan was developed to cover all case scenarios that could be encountered during the performance of field activities.

2.3 OBJECTIVES

The objective of this project is to acquire data to define the nature and extent of groundwater contamination, to complete a remedial investigation/feasibility study (RI/FS) and to prepare a risk assessment that evaluates the risks to human health and the environment posed by the SCGW. The RI/FS will gather sufficient information to support an informed decision on selecting the most appropriate remedial action to be applied in the remediation of this site.

The U.S. Army Corps of Engineers prepared an Off-Base Groundwater Investigation Report Northeast of Tinker AFB in 1990 and 1991 during which several monitoring wells were installed (USACE, 1991). Chemical analysis of groundwater samples indicated the presence of organic compounds chlorobenzene, dichlorobenzene, 1,2-dichloroethene, trichlorethene, tetrachloroethene, vinyl chloride, benzene, toluene, ethylbenzene and xylene and inorganic compound chromium. Some of these compounds were detected at levels slightly above maximum contaminant levels (MCLs).

The scope of work will include:

- Performing a historical review of the site.
- Geophysically logging and sampling twelve private wells.
- Determining daily discharge rates for Soldier Creek and estimating seasonable direction and volume fluctuations of water moving between Soldier Creek and the underlying aquifer.
- Drilling four continuous cores to a depth of up to 200 feet each for detailed lithological information. Conducting geophysical surveys of the core holes and the cores.
- Drilling twelve holes to a depth of 180 feet each, and installing twelve monitoring well clusters, each consisting of three wells with approximate depths of 40, 90 and 150 feet. Representative water samples shall be collected from each of these wells.
- Developing a conceptual model of the geology and of the groundwater/surface water interactions at the site.
- Conducting three long-term aquifer pump tests to determine aquifer parameters for Tinker AFB's conceptual model. The test will be performed on three aquifer zones at approximate depths of 40, 90, and 150 feet.
- Collecting soil samples in the vicinity of each of the twelve private wells sampled for groundwater. Four grab samples for chemical analyses will be collected from each location at depths of 0, 1, 2.5 and 5 feet.
- Collecting stream sediment samples at twenty locations. Five samples for chemical analyses will be collected from each location at depths of 0, 1, 2, 3, and 5 feet.
- Analyzing groundwater samples collected during this RI/FS for the 129 Priority Pollutants (except dioxin and asbestos). Analyze soil and sediment samples for U.S. Environmental Protection Agency (EPA) Target Compound List (TCL) analytes (except pesticides), arsenic, barium, chromium (total and hexavalent), cadmium, copper, lead, mercury, nickel, selenium, silver, and zinc.

Each of the tasks outlined above is described in detail in the RI/FS Work Plan (ES, 1994a).

SECTION 3

PROJECT TEAM ORGANIZATION

3.1 RESPONSIBILITIES

The project team assigned to the Tinker AFB project is outlined below:

Name	Task Assigned
Charlie Spiers	ES Technical Director
Dr. John Yu	ES Project Manager
Randy Palacek	ES Office Health and Safety Manager
Marc Harder	ES Site Health and Safety Officer
Laura Brock	ES Alternate Site Health and Safety Officer
John Osweiler	ES Field Team Leader/RI Manager

ES project personnel responsibilities are outlined in Table 3.1. The site safety organization is structured such that field team members report to the Site Health and Safety Officer (SHSO) who, in turn, reports to the Office Health and Safety Manager for safety-related issues. Subcontractors report to their own health and safety personnel.

Table 3.1 ES Personnel Responsibilities

Title	General Description	Responsibilities
Technical Director	Upper management. Assists project personnel on technical issues.	• Provide technical information for field activities. • Advise Project Manager.
Project manager	Reports to upper-level management. Has authority to direct response operations. Assumes total control over site activities.	• Prepares and organizes the background review of the situation, the work plan, the site safety plan, and the field team. • Obtains permission for site access and coordinates activities with appropriate officials. • Ensures that the work plan is completed and on schedule. • Briefs the field teams on their specific assignments. • Uses the site safety and health officer to ensure that safety and health requirements are met. • Prepares the final report and support files on the response activities. • Serves as liaison with public officials.
Office Health and Safety Manager	Advises the Project Manager and Site Health and Safety Officer on safety related issues.	• Oversees preparation of health and safety plan. • Approve H&S plan. • Provides information regarding project safety issues to site health and safety officer. • Serves as liaison with public officials.
Site Health and Safety Officer	Enforces the H&S plan requirements on site. Advises the Project Manager and Office Health and Safety Manager on all aspects of health and safety on site. Stops work if any operation threatens worker or public health or safety.	• Periodically inspects protective clothing and equipment. • Ensures that protective clothing and equipment are properly stored and maintained. • Controls entry and exit at the access control points. • Coordinates safety and health program activities with project safety officer. • Confirms each team member's suitability for work based on a physician's recommendation. • Administers the site and personnel air monitoring program. • Monitors the work parties for signs of stress, such as cold exposure, heat stress, and fatigue. • Implements the site safety plan. • Conducts periodic inspections to determine if the site safety plan is being followed. • Knows emergency procedures, evacuation routes, and the telephone numbers of the ambulance, local hospital, poison control center, fire department, and police department. • Notifies, when necessary, Tinker AFB emergency officials.

Table 3.1, continued

Title	General Description	Responsibilities
Site Health and Safety Officer (continued)		• Coordinates emergency medical care. • Sets up decontamination lines and the decontamination solution appropriate for the potential type of chemical contamination on site. • Controls the decontamination of all equipment, personnel, and samples from the contaminated areas. • Assures proper disposal of contaminated clothing and materials. • Ensures that all required equipment is available. • Advises medical personnel of potential exposures and consequences. • Notifies emergency response personnel by telephone or radio in the event of an emergency.
Field Team Leader	Responsible for field team operations and safety.	• Manages field operations. • Executes the work plan and schedule. • Enforces safety procedures. • Coordinates with the site safety officer in determining protection level. • Enforces site control. • Documents field activities and sample collection. • Serves as liaison with public officials.
Work Team	The work party must consist of at least two people, one of whom is an ES employee.	• Safely complete the onsite tasks required to fulfill the work plan. • Notify project health and safety officer or supervisor of suspected unsafe conditions. • Take precautions necessary to prevent injury to themselves and other employees. • Implement the site and personnel air monitoring program. • Comply with project health and safety plans. • Maintain visual contact between partners (buddy system). • Perform only those tasks they believe they can do safely. • Immediately report any accidents and/or unsafe conditions to the field team leader, or any deviations from this plan.

SECTION 4

SITE-SPECIFIC EMPLOYEE TRAINING AND MEDICAL MONITORING REQUIREMENTS

Listed below are health and safety training and medical monitoring requirements for this project.

4.1 SAFETY TRAINING REQUIREMENTS

All personnel involved in the project field work must be adequately trained and thoroughly briefed on anticipated hazards, equipment to be worn, safety practices to be followed, emergency procedures, and communications.

All site personnel will be trained in accordance with OSHA requirements as contained in 29 CFR 1910.120, Hazardous Waste Operations and Emergency Response and 29 CFR 1910.1030, Bloodborne Pathogens Standard. Employees will not participate in field activities until they have been trained to the level required by their job function and responsibility. All training and field experience used to satisfy the requirements of 29 CFR 1910.120 must be thoroughly documented. Appendix E contains documentation of employee training.

In addition, all personnel involved in field investigation activities will have completed Red Cross or equivalent first-aid and cardiopulmonary resuscitation (CPR) courses. All training documentation will be verified by the SHSO.

Consistent with OSHA 29 CFR 1910.120, individuals designated as site H&S supervisors must receive an additional 8 hours of specialized training on managing hazardous waste operations. Such training will also be documented.

ES personnel participating in investigation activities at Tinker AFB receive annual comprehensive medical examinations and a termination examination. The medical monitoring program meets the requirements of 29 CFR 1910.120. ES also requires that the drilling subcontractors have their own annual medical monitoring program.

4.2 SITE-SPECIFIC SAFETY BRIEFINGS

Site-specific safety and health briefings will be conducted by a qualified ES Health and Safety representative for all personnel who will engage in the field investigation activities. This training will specifically address the activities, procedures, monitoring, and equipment applicable to the site's operations, as well as site or facility layout, potential hazards, and emergency response services at the site. Indi-

vidual responsibilities regarding health and safety procedures during field work will be clarified. An initial safety briefing will be conducted for each new employee on site. Safety briefings will also be conducted and documented daily. Additional topics that will be addressed at the safety briefings may include:

- Names of responsible health and safety personnel;
- Site hazards;
- Exposure risk;
- Symptoms of exposure and exposure treatment for contaminants;
- Personal protective equipment (PPE) to be used and location;
- Decontamination procedures to be followed;
- Routes to hospitals and location of first aid kits and related items;
- Personal monitoring equipment, use and calibration;
- Accident investigation and reporting, shipping, and waste disposal procedures;
- Review of planned activities;
- Defined safety procedures to be followed during sampling operations; and
- Emergency communication and evacuation procedures.

Documentation of these briefings will be made in the SHSO's logbook. It will include the name of each person in attendance and the topics discussed.

SECTION 5

SAFETY AND HEALTH RISK ANALYSIS

5.1 INTRODUCTION

Hazardous substances which may be present at Tinker AFB include organic compounds and heavy metals. Table 5.1 lists health hazard qualities of compounds that may be encountered at the site.

In addition to the hazardous substances present on the site, some physical hazards or hazardous conditions may be expected at the site. These include heat and cold exposure, and organisms such as snakes and scorpions.

Employees must implement safe work practices while working on site. Protective clothing will reduce many of the on-site risks; however, protective clothing and respirators will increase heat stress. Heat stress monitoring is discussed in detail in Section 5.3.

5.2 CHEMICAL HAZARDS

Within Tinker AFB, investigative personnel may be exposed to numerous groups of chemical toxicants by both the respiratory and percutaneous (skin absorption) routes. The risk of exposure and the severity of the resultant physiologic reaction to any of the contaminants is determined chiefly by their inherent toxicity, concentration, physical characteristics, duration of exposure, and individual susceptibility or hypersensitivity.

The field team may be exposed to contaminants in soils and groundwater through inhalation, ingestion, and skin and eye contact.

- Skin contact with contaminated solid or liquid samples can occur when a worker does not wear proper protective clothing around sampling activities.
- Eye contact with contaminated liquid or solid samples can occur when a worker does not wear protective eyewear at locations where samples are being taken or handled.
- Respiratory system contact with hazardous airborne materials can occur from lack of or improper use of respiratory equipment.

Table 5.1 Health Hazard Qualities of Hazardous Substances of Concern

Compound	PEL[a]/TLV[b] (ppm)	IDLH[c] (ppm)	Odor Threshold[d] (ppm)	Ionization Potential (eV)[e]	Physical Description/Health Effects/Symptoms
Arsenic	0.01 mg/m^3 (PEL) 0.2 mg/m^3 (TLV)	100 mg/m^3	NA	NA	Grayish-yellow, white or reddish gray crystalline powder. Silver gray or tin-white, brittle, odorless solid. Affects liver, kidneys, skin, lungs. Carcinogen.
Barium (soluble compounds as Ba)	0.5 mg/m^3 (PEL & TLV)	1,100 mg/m^3	NA	NA	Appearance and properties vary with specific compounds. Irritates eyes, skin, and upper respiratory tract. Causes gastroenteritis, muscle spasms, slow pulse and heartbeat irregularities.
Benzene	1 (PEL)	3,000	4.7	9.24	Colorless to light-yellow liquid with aromatic odor. Eye, nose, and respiratory system irritant. Causes giddiness, headaches, nausea, staggered gait, fatigue, and bone marrow depression. Chronic exposure has been linked to leukemia. Carcinogen.
Cadmium (dust)	0.005 mg/m^3 (PEL)	50 mg/m^3	NA	NA	Silver-white, blue-tinged, lustrous, odorless metal. Causes pulmonary edema when inhaled. When ingested, causes coughing, chest tightness/pain, chills, muscle aches, headaches, nausea vomiting, diarrhea, and mild anemia. Attacks respiratory system, kidneys, prostate, and blood. Carcinogen.
Chlorobenzene	10 (TLV)	2,400	0.21 - 60	9.07	Colorless liquid with almond-like odor. Eye, nose, skin irritant; causes dizziness and headache.
Chromium (III)	0.5 mg/m^3 (PEL & TLV)	NA	NA	NA	Properties vary with compound; irritates skin.
Chromium (VI)	0.05 mg/m^3 (TLV)	30 mg/m^3	NA	NA	Properties vary with compound. Causes eye, respiratory and skin irritation. Attacks blood, liver, and kidneys. Carcinogen.
Copper (dust/mists)	1 mg/m^3 (PEL & TLV)	NA	NA	NA	Reddish, lustrous, odorless metal. Irritates eyes, nose and skin and causes a metallic taste. May affect liver and kidneys.

Table 5.1, cont.

Compound	PEL[a]/TLV[b] (ppm)	IDLH[c] (ppm)	Odor Threshold[d] (ppm)	Ionization Potential (eV)[e]	Physical Description/Health Effects/Symptoms
Cyanides (as CN)	5 mg/m^3 (PEL & TLV)	50 mg/m^3	NA	NA	White, granular or crystalline solid with a light almond-like odor. Asphyxia and death can occur; causes weakness, confusion, headache, vomiting, and respiratory symptoms. Skin and eye irritant.
1,2 Dichlorobenzene	50 (TLV)	1,000	0.02 - 50	9.06	Colorless to pale yellow liquid with a pleasant aromatic odor. Irritates nose, eyes. Effects liver, kidneys and can cause skin blisters.
Dichloroethene (DCE)	200 (PEL & TLV)	4,000	0.085-500	9.65	Clear liquid with chloroform-like odor. Irritates eyes, respiratory system. CNS[f] depressant.
Ethyl benzene	100 (TLV)	2,000	0.25-200	8.76	Colorless liquid with an aromatic odor. Eye, skin, and mucous membrane irritant. Causes headaches, narcosis, coma.
Lead	0.05 mg/m^3 (PEL)	700 mg/m^3	NA	NA	Heavy, ductile, gray metal. Irritates eyes and causes brain, kidney, blood, CNS, and digestive tract disorders. Symptoms include weakness, insomnia, abdominal pain, colic, constipation, anemia, wrist and ankle paralysis, and low blood pressure.
Mercury (aryl and inorganic)	0.1 mg/m^3 (skin, ceiling) (PEL & TLV)	NA	odorless	NA	Silver-white, heavy, odorless liquid metal. Can cause irritation of skin and eyes, coughing, bronchitis, fatigue, weakness, weight loss, and headaches.
Mercury (alkyl)	0.01 mg/m^3 (skin) (PEL & TLV)	10 mg/m^3	NA	NA	Appearance and odor vary depending on the specific (organo) alkyl compound.
Selenium	0.2 mg/m^3 (PEL & TLV)	NA	0.0002 mg/m^3 aa/	NA	Amorphous or crystalline, red to gray solid. Irritates eyes, skin, and upper respiratory system. Attacks liver, kidneys, and blood.
Silver	0.01 mg/m^3 (PEL & TLV)	NA	NA	NA	White lustrous solid. Attacks skin, eyes, throat, nasal septum, and gastrointestinal system.
Tetrachloroethene (Tetrachloroethylene or Perchloroethylene)	25 (PEL)	500	5-50	9.3	Colorless liquid with chloroform odor. Eye, nose, throat irritant. Cumulative liver and CNS damage. Suspected carcinogen and mutagen.

Table 5.1, cont.

Compound	PEL[a]/TLV[b] (ppm)	IDLH[c] (ppm)	Odor Threshold[d] (ppm)	Ionization Potential (eV)[e]	Physical Description/Health Effects/Symptoms
Toluene	50 (TLV)	2,000	0.17-40	8.82	Colorless liquid with sweet, pungent odor. Causes dizziness, headache, dilated pupils. Targets skin, liver, kidneys, and CNS. Suspected teratogen and mutagen.
Trichloroethene (Trichloroethylene or TCE)	50 (PEL & TLV)	1,000	21-400	9.4	Colorless liquid (sometimes dyed blue) with chloroform-like odor. Suspected carcinogen, narcotic, anesthetic.
Vinyl Chloride	1 (PEL)	NA	260	10.0	Colorless gas with pleasant odor at high concentrations. Causes weakness, abdominal pain, and gastrointestinal bleeding. Attacks liver, CNS, blood, respiratory system and lymphatic system. Carcinogen.
Xylenes	100 (TLV)	1,000	0.05-200	8.5	Colorless liquid with aromatic odor. Causes dizziness, drowsiness, staggered gait, irritation of eyes, nose, skin and throat, nausea, vomiting, and abdominal pain. Also targets blood, liver, kidneys, and skin.
Zinc (based on zinc oxide)	5 mg/m^3 (PEL)	NA	NA	NA	Fine, white, odorless particulate. Irritates respiratory system. Causes metallic taste, cough, chills, fever, tight chest, rales, headache, blurred vision, muscle cramps, nausea and vomiting.

Notes:

a PEL: Permissible Exposure Limit. OSHA-enforced average air concentration to which a worker may be exposed for an 8-hour workday without harm. PELs are published in 29 CFR 1910.1000. Expressed as parts per million (ppm) unless noted otherwise.

b TLV-TWA: Threshold Limit Value - Time-weight Average. Average air concentration (same definition as PEL) recommended by the American Conference of Governmental and Industrial Hygienists (ACGIH).

c IDLH: Immediately Dangerous to Life or Health. Air concentration at which an unprotected worker can escape without debilitating injury or health effects. Expressed as ppm unless noted otherwise.

d When a range is given, use the highest concentration.

e eV = Electron volt

f CNS = Central nervous system

- Gastrointestinal system contact with samples can occur when workers do not pay attention to personal hygiene rules designed to reduce the chance of ingesting site contaminants (i.e., hand washing before smoking, eating, or drinking).

5.2.1 Organic Solvents

Several halogenated and non-halogenated solvents are found or suspected at Tinker AFB. Organic solvents can acutely affect the central nervous system. Depending on the degree of exposure and the solvent involved, these effects may range from mild narcosis to death from respiratory failure. Vapors from organic solvents could be encountered during the drilling of soil borings and continuous cores, while conducting the pump tests, and during any soil, sediment, surface water, or groundwater sampling activity. Organic vapors can build up under confined conditions such as in a well casing, or in any unventilated environment where there is a solvent source.

Organic vapor monitoring will be conducted periodically or continuously, when necessary during the field investigation activities at Tinker AFB. Section 8.1.1. of this document, outlines the procedures that will be carried out for monitoring of organic vapors.

5.2.2 Heavy Metals

The principal metal of concern is chromium. Chromium exhibits variable toxicity depending on its valence state. Chromium VI, a carcinogen, causes eye, respiratory, and skin irritation and attacks the blood, liver, and kidneys. Chromium could be present during field activities as airborne particulate matter. It would occur in the form of dust or soil that has become airborne as a result of drilling or sampling activities.

Monitoring for particulates in the air will be conducted by the methods outlined in Section 8.1.4 of this document. Precautionary measures to avoid unnecessary exposure to dust particles during drilling are outlined in Section 5.2.5.

5.3 PHYSICAL AND ENVIRONMENTAL HAZARDS

Personnel may be exposed to physical hazards at any time while working at the site. Physical hazards may include noise, exposure to potentially harmful biological organisms and poisonous plants, as well as slips, trips, falls, and the hazards resulting from working with heavy equipment. Personnel must be alert and aware of their working environment at all times.

5.3.1 Biological Organisms

There is potential for contact with biological organisms or pathogens which may cause injury or disease exists when performing investigative activities at the SCGW operable unit. Sturdy work clothes and shoes will be worn by field personnel in order to help prevent injuries.

Snakes may be present in the area and caution should be taken especially when working in previously undisturbed areas and locations with animal dens.

Spiders and scorpions may be present on site. A spider bite may result in severe pain, illness, and possible death from complications, but usually not from the bite itself. A scorpion sting is very painful, but usually will not result in death.

Ticks or chiggers may be nuisances to field personnel. Chiggers may be repelled using over-the-counter insect repellents. Bites from deer ticks may result in the transmission of Lyme disease. The disease is caused by a spirochete bacterium which infects deer ticks. The ticks bite humans and transfer the bacterium into the bloodstream. Transmission of the disease occurs mostly in the late spring and early summer, and is characterized by flu-like symptoms, a red ring on the skin, and a localized burning sensation. Personal protective equipment will offer some protection, but the use of insect repellent with DEET on outside clothing also may be warranted. Personnel shall perform self-searches after each day to check for ticks.

5.3.2 Poisonous Plants

Skin contact with poison ivy can cause swelling, breathing difficulty, blisters, fever, and severe itching. Poison ivy commonly grows along river and creek banks and is poisonous year-round. To prevent contact with poison ivy, personnel should wear long sleeves, long pants and gloves. If contact is suspected, the affected area shall immediately be washed with soap and water and clothes shall be changed. Poison ivy oils may remain on clothing or equipment until they are washed. Figure 5.1 describes poison ivy and steps that shall be taken if a person has had skin contact with poison ivy.

5.3.3 Noise

High noise levels are anticipated to be found in the vicinity of operating drilling equipment, other heavy machinery, and in the vicinity of jet traffic. Field personnel should use the appropriate hearing protection when working in these areas. Unprotected long-term exposure to noise above 85 decibels (dB) can result in hearing loss.

5.4 HAZARD EVALUATION

To ensure a strong safety awareness program during borehole and corehole drilling, monitoring well construction, performing the pumping tests, and during all sampling activities, personnel must have adequate training, this health and safety plan must be communicated to the employees, and standing work orders must be developed and communicated to the employees. Sample standing orders for personnel entering the exclusion zone are as follows:

- No smoking, eating, drinking.
- No matches or lighters in zone.
- No personal vehicles allowed in the exclusion zone or contamination reduction zone.
- Check in and check out at access control points.

Figure 5.1

Poison Ivy, Oak, & Sumac

Remove affected clothing and flush contact area with water. Wash thoroughly with warm water and soap, then swab with alcohol soon after exposure.

Has the person inhaled smoke from burning poisonous plants?

Yes → Seek medical care. If person is unable to walk, obtain emergency assistance. If assistance will be delayed and person is having difficulty breathing, give antihistamine (Benadryl).

No

If external rash and blisters appear, apply cold, wet compresses, then calamine lotion, taking care near eyes. For heavy blistering and oozing, use cold, wet compresses of 1 Tbs. salt to 1 cup of water.

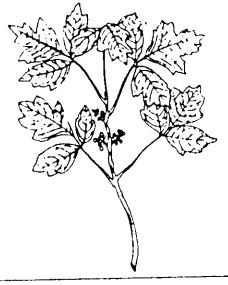
If breathing or pulse stops, see *Artificial Respiration/CPR*, pp. 4–7.

If serious swelling, breathing difficulty, blisters, fever, severe itching, or other reaction occurs, seek medical care.

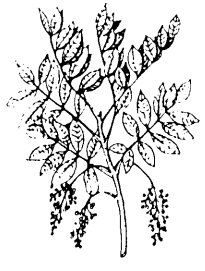
Calm the person by talking while attending to the problem. Explain what you are doing. Try not to show anxiety; act with confidence. Your calm behavior can help to reassure the injured person.

Recognize common poison plants:

Poison Ivy
Small plant, vine, or shrub common throughout U.S. except California. Shiny leaves grow in clusters of three, turning red and yellow toward fall.



Poison Oak
Western variety grows in California and portions of adjacent states as shrub or vine closely resembling poison ivy.
More common variety grows in other areas, usually as a shrub with clusters of hairy, yellowish berries and undersides of leaves covered with hair.



Poison Sumac
Woody shrub or small tree (5–25 feet) grows in eastern U.S., especially in moist climates.
Each leaf stalk has 7–13 leaflets with smooth edges, which turn red in fall, and cream-colored berries which hang from branches in loose clusters.

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- Use buddy system.
- Wear appropriate personal protective equipment.
- Avoid walking through puddles or stained soil.
- Discovery of unusual or unexpected conditions will result in immediate evaluation and reassessment of site conditions and health and safety practices.
- Conduct safety briefings prior to onsite work.
- Take precautions to reduce injuries from heavy equipment and other tools.

The following guidelines will be followed while working on site:

- Heavy equipment: Only qualified operators will be allowed to operate heavy equipment. Subcontractors will be required to use the safe work guidelines should be practiced if climbing activities are required. Conditions of the footing and the need for spotting should be determined prior to initiating a climb.

5.4.1 Drilling

Before any drilling or augering operations are performed, efforts must be made to determine if underground installations (i.e., sewers, telephone, water, fuel, electrical lines, or liners) are present in the vicinity and, if so, exactly where such underground installations are located. Drilling locations may be adjusted in the field to avoid underground obstructions. Base engineering shall be contacted before starting any subsurface activities and information concerning buried utilities shall be obtained. In addition, appropriate distance should be maintained from overhead electrical lines.

The drilling rig is heavy equipment, and all field personnel must be careful in the drilling area. The rig is used to hoist and turn augers, drill rods, hammers, and other heavy tools or equipment.

All equipment on the rig will be inspected periodically as required by applicable regulations for conditions of ropes, cables, hooks, U-bolts or other hoisting harnesses which, if defective, may drop heavy objects on individuals working in the vicinity of the rig. Hard hats and steel-toed boots are mandatory for all personnel working behind an operating rig.

Airborne dust is the primary route of exposure to metals such as chromium since they are not volatile. All employees on site will avoid exposure to excess dust particles. Dust masks and goggles will be worn when dust cannot be physically avoided.

5.4.2 Sediment Sampling

Field personnel shall be cautious of splash hazards when obtaining sediment samples. Use of the appropriate PPE will help to minimize risks of liquid contact with the skin.

Areas where sediment samples are obtained are frequently wet and can result in slip, trip, and fall hazards. Field personnel will survey each sample collection location to determine the safest route and method of sampling.

When working in a boat or in a creek that is deeper than 2 to 3 feet, personal flotation devices (PFD) should be worn.

5.4.3 Surface Water Gaging

Measurements of river discharge are made under a wide range of conditions. Personnel performing surface water gaging will know how to swim and will wear PFD as necessary. Discharge measurements through ice may be necessary. In advancing across an ice-covered stream, the ice will be tested with a sharp blow of the ice chisel every few steps. A few inches of new snow on top of the ice may conceal dangerous places that would be apparent if there was no snow.

5.4.4 Groundwater Sampling and Pumping Tests

Organic vapors may be trapped in monitoring wells under the well cap. A well headspace measurement will be made immediately after opening each well. In addition, the breathing zone will also be monitored with an HNU (or equivalent). These measurements will be used to determine the level of protection required for groundwater sampling activities.

Field personnel shall also be cautious of splash hazards when obtaining groundwater samples. Use of the appropriate PPE will help to minimize risks of liquid contact with the skin.

Areas around the wells can be wet and may result in slip, trip, and fall hazards. Field personnel will survey each sample collection location to determine the safest route and method of sampling.

5.4.5 Flammable Solvent Storage

Small quantities of flammable solvents may be used on site as decontamination solutions. Care shall be taken by field team members to properly label all containers in accordance with the OSHA Hazard Communication Standard, 29 CFR 1910.1200, and the ES Hazard Communication Policy. All solvents must be contained in approved (UL and FM) safety containers. A fire extinguisher will be maintained within 50 feet of any flammable storage area.

Material Safety Data Sheets (MSDSs) for approved solvents and contaminants of concern are contained in Appendix B of this plan. Chemical profiles for the elements cadmium, chromium, lead, and nickel are also provided in Appendix B. If other solvents are required, field team members must obtain a MSDS and approval of the SHSO prior to bringing the solvent to the work site.

5.4.6 Confined Space Entry

There are no confined space entries included in the scope of work, and there are not any anticipated during the field efforts.

5.5 HEAT STRESS

Adverse weather conditions are important considerations in planning and conducting site operations. Hot or cold weather can cause physical discomfort, loss of efficiency, and personal injury. Of particular importance is heat stress resulting when protective clothing decreases natural body ventilation. Heat stress can occur even when temperatures are moderate if employees are wearing impermeable protective clothing. One or more of the following recommendations will help reduce heat stress:

- Provide plenty of liquids to replace body fluids. Water and/or commercial electrolyte mixes should be available on site.
- Provide cooling devices to aid natural body ventilation. These devices, however, add weight, and their use should be balanced against worker efficiency.
- Wear cotton long underwear, which acts as a wick to help absorb moisture and protect the skin from direct contact with heat-absorbing protective clothing.
- Install mobile showers and/or hose-down facilities to reduce body temperature and cool protective clothing.
- In extremely hot weather, conduct non-emergency response operations in the early morning or evening.
- Ensure that adequate shelter is available to protect personnel against heat, sun, or other adverse weather conditions which decrease physical efficiency and increase the probability of accidents.
- In hot weather, rotate workers wearing protective clothing.
- Maintain good hygienic standards, frequently changing clothing and daily showering. Clothing should be permitted to dry during rest periods. Workers who notice skin problems should immediately inform the SHSO who will in turn consult medical personnel.

5.5.1 Effects of Heat Stress

If the body's physiological processes fail to maintain a normal body temperature because of excessive heat, a number of physical reactions can occur. They can range from mild symptoms such as fatigue, irritability, anxiety, and decreased concentration, dexterity, or movement, to death. The location of a first-aid manual detailing specific first-aid treatment for mild cases of heat stress should be known at all times by the SHSO to ensure that it is readily available for reference in the field. Medical help must be obtained for the more serious cases of heat stress.

5.5.2 Heat-Related Problems

- **Heat rash**: Caused by continuous exposure to heat and humid air and aggravated by chafing clothes. Decreases ability to tolerate heat and is a nuisance.

Figure 5.2

53 Heat Exhaustion/ Heat Cramps

Signs & Symptoms: *cool, pale, clammy skin/fatigue and faintness/headache/ heavy sweating/weak pulse/near-normal body temperature/nausea. Onset is gradual. Person is alert.*

If person is unconscious or groggy, see *Heatstroke*, p. 54.

If possible, bring person indoors to a cool room. (Use air conditioner or electric fan or open windows and fan vigorously.) Outdoors, move person to a shaded area.

Have the person lie down. Elevate legs and feet with pillows or rolled blankets.

Loosen or remove clothing. Cool the skin with cool, wet sponges or cloths applied to forehead, arms, and legs.

See illustration on opposite page.

If the person has *no* heart problems or high blood pressure and is fully conscious, give sips of a salt solution (1 tsp. salt to 16 ounces—2 cups—water) every 15 minutes for about one hour. Check body temperature every 5 minutes and continue to cool with wet cloths.

If the person complains of muscle cramps, do not massage cramped muscles. This may increase pain.

Does temperature suddenly rise? Are there convulsions, stupor, or unconsciousness?

Yes → If any of these occur, see *Heatstroke*, p. 54.

No

Calm the person by talking while attending to the problem. Explain what you are doing. Try not to show anxiety; act with confidence. Your calm behavior can help to reassure the sick person.

Does the person begin to feel better after one hour?

Yes → Keep person out of the sun and as cool and comfortable as possible.

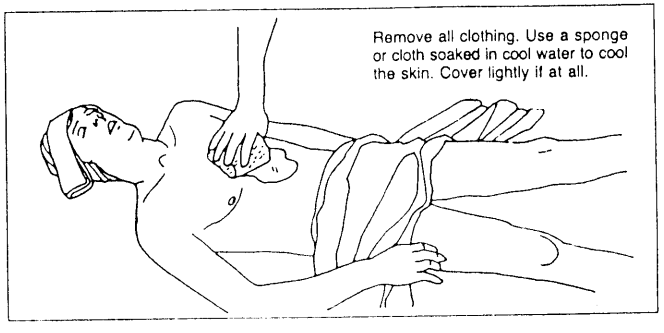
No

Seek medical care immediately. While awaiting assistance, continue cooling with wet cloths and checking body temperature frequently.

Person should be checked by a doctor as a precaution. Discourage unnecessary exercise; this person may now be more susceptible to heat. If symptoms reappear, repeat process and call a physician.

Smelling salts, held briefly under the nose, may help to stimulate the person.

If the temperature suddenly rises or convulsions, stupor, or unconsciousness develop, see *Heatstroke*, p. 54.



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- **Heat cramps**: Caused by profuse perspiration with inadequate fluid intake and chemical replacement, especially salts. Signs include muscle spasms and pain in the extremities and abdomen. Figure 5.2 describes the actions that should be taken to relieve heat cramps.
- **Heat exhaustion**: Caused by increased stress on various organs to meet increased demands to cool the body. Signs include shortness of breath; increased pulse rate (120-200 beats per min.); pale, cool, moist skin; profuse sweating; and dizziness and lassitude. Figure 5.2 describes the actions that should be taken to relieve heat exhaustion.
- **Heat stroke**: The most severe form of heat stress. Body must be cooled immediately to prevent severe injury and/or death. Signs include red, hot, dry skin; no perspiration; nausea; dizziness and confusion; strong, rapid pulse; and possibly coma. Medical help must be obtained immediately. Figure 5.3 describes the actions that should be taken in route to the hospital or while waiting for an ambulance.

5.5.3 Heat-Stress Monitoring

Monitoring of personnel wearing impervious clothing will begin when the ambient temperature is 70°F or above. Monitoring of heat stress for other working conditions will occur at the worker's request, at the discretion of the SHSO, or as conditions change. Table 5.2 presents the suggested frequency for such monitoring. Monitoring frequency will increase as the ambient temperature increases or as slow recovery rates are observed. Heat-stress monitoring will be performed by a person with a current first-aid certification who is trained to recognize heat-stress symptoms. For monitoring the body's recuperative abilities from excess heat, one or more of the techniques listed below will be used. Other methods for determining heat-stress monitoring, such as the wet bulb globe from the American Conference of Governmental Industrial Hygienists (ACGIH) Threshold Limit Values (TLV) Booklet, may be used.

To monitor the worker, measure:

- **Heart rate**: Count the radial pulse during a 30-second period as early as possible during the rest period.
  - If the heart rate exceeds 110 beats per minute at the beginning of the rest period, the next work cycle will be shortened by one-third and the rest period will remain the same.
  - If the heart rate still exceeds 110 beats per minute at the next rest period, the following work cycle will be reduced by one-third.
- **Oral temperature**: Use a clinical thermometer (3 minutes under the tongue) or similar device to measure the oral temperature at the end of the work period (before drinking).
  - If oral temperature exceeds 99.6°F (37.6°C), the next work cycle will be reduced by one-third without changing the rest period.

Figure 5.3

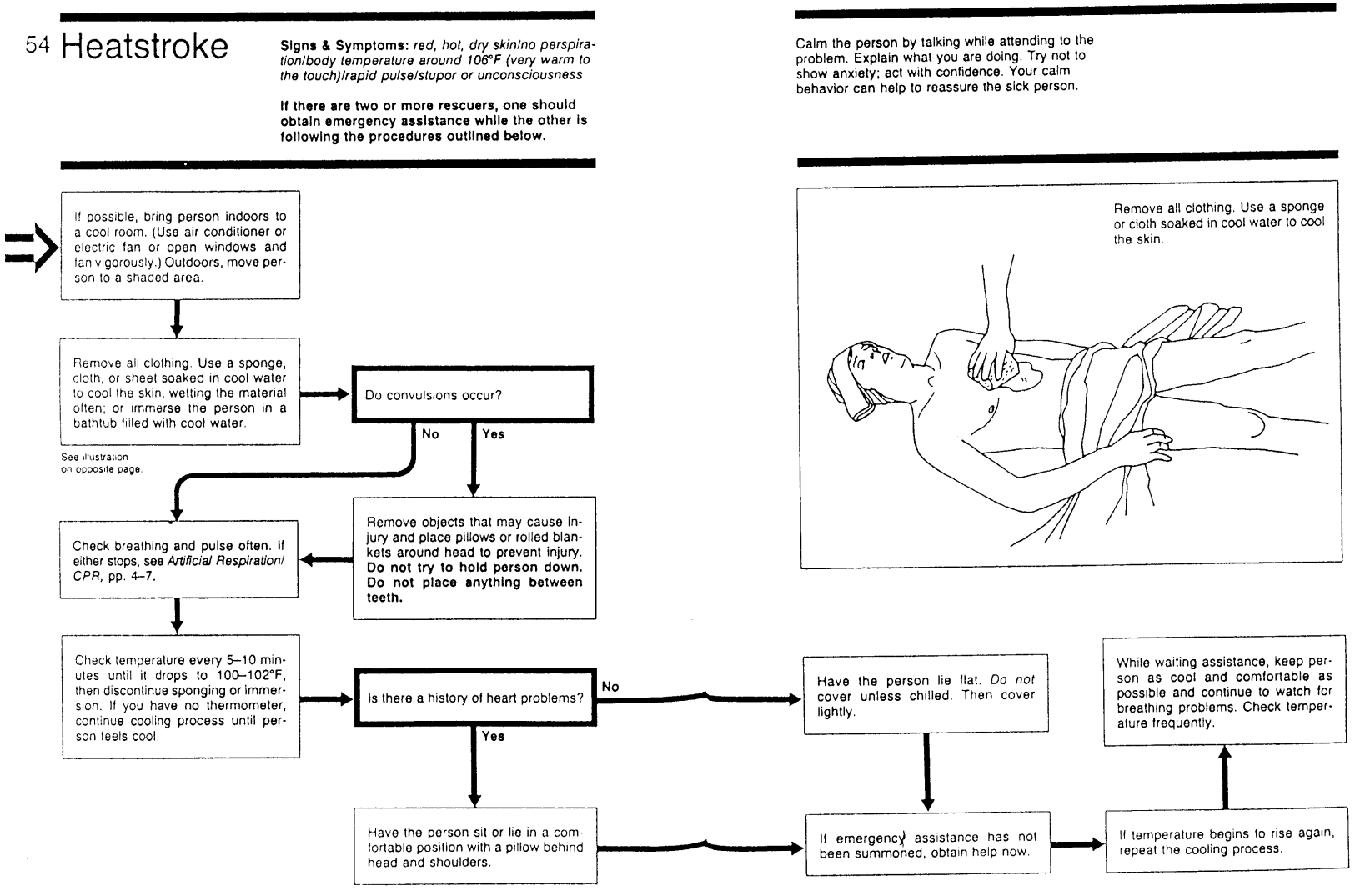

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Table 5.2 Suggested Frequency of Physiological Monitoring for Fit and Acclimatized Workers[1]

Adjusted Temperature[2]	Normal Work Ensemble[3]	Impermeable Ensemble
90°F (32.2°C) or above	After each 45 minutes of work	After each 15 minutes of work
87.5-90°F (30.8-32.2°C)	After each 60 minutes of work	After each 45 minutes of work
82.5-87.5°F (28.1-30.8°C)	After each 90 minutes of work	After each 60 minutes of work
77.5- 82.5°F (25.3-28.1°C)	After each 120 minutes of work	After each 90 minutes of work
72.5- 77.5°F (22.5-25.3°C)	After each 150 minutes of work	After each 120 minutes of work

[1] For work levels of 250 kilocalories/hr.

[2] Calculate the adjusted air temperature (t_a adj) by using this equation: t_a adj °F + (13 x % sunshine). Measure air temperature (t_a) with a standard mercury-in-glass thermometer, with the bulb shielded from radiant heat. Estimate percent sunshine by judging what percent of time the sun is not covered by clouds that are thick enough to produce a shadow (100 percent sunshine - no cloud cover and a sharp, distinct shadow; 0 percent sunshine - no shadows).

[3] A normal work ensemble consists of cotton coveralls or other cotton clothing with long sleeves and trousers.

- If oral temperature still exceeds 99.6°F (37.6°C) at the beginning of the next rest period, the following cycle will be reduced by one-third.
- No worker will be permitted to wear a semipermeable or impermeable garment when oral temperature exceeds 100.6°F (38.1°C).

5.6 COLD EXPOSURE

Persons working outdoors in temperatures at or below freezing may suffer from cold exposure. During prolonged outdoor periods with inadequate clothing, effects of cold exposure may even occur at temperatures well above freezing. Cold exposure may cause severe injury by freezing exposed body surfaces (frostbite) or result in profound generalized cooling (hypothermia), possibly causing death. Areas of the body that have high surface-area-to-volume ratios, such as fingers, toes, and ears, are the most susceptible to frostbite.

Local injury resulting from cold is included in the generic term frostbite. There are several degrees of damage. Frostbite of the extremities can be categorized into:

- **Frost nip or incipient frostbite**: characterized by suddenly blanching or whitening of skin.
- **Superficial frostbite**: skin has a waxy or white appearance and is firm to the touch, but tissue beneath is resilient.
- **Deep frostbite**: tissues are cold, pale, and solid; extremely serious injury.

Systematic hypothermia is caused by exposure to freezing or rapidly dropping temperature. Its symptoms are usually exhibited in five stages: (1) shivering and incoordination; (2) apathy, listlessness, sleepiness, and (sometimes) rapid cooling of the body to less than 95°F; (3) unconsciousness, glassy stare, slow pulse, and slow respiratory rate; (4) freezing of the extremities; and (5) death.

If work is conducted at ambient temperatures below 39°F (4°C), workers shall wear cold protective clothing appropriate for the level of cold and physical activity. If the available clothing does not give adequate protection to prevent hypothermia or frostbite, work shall be modified or suspended until adequate clothing is made available or until weather conditions improve.

If work is to be performed at temperatures below 20°F, heated shelters shall be made available, and employees will break to seek warmth at regular intervals, the frequency depending on the severity of exposure. The onset of shivering will require immediate return to the warm shelter for a period of time necessary for the employee to warm up. Figure 5.4 describes the actions that shall be taken when an employee is suffering from cold exposure.

5.6.1 Evaluation and Control

For exposed skin, continuous exposure shall not be permitted when the air speed and temperature result in an equivalent chill temperature of -32°C (-25.6°F). Superficial or deep local tissue freezing will occur only at temperatures below -1°C (30.2°F) regardless of wind speed.

Figure 5.4

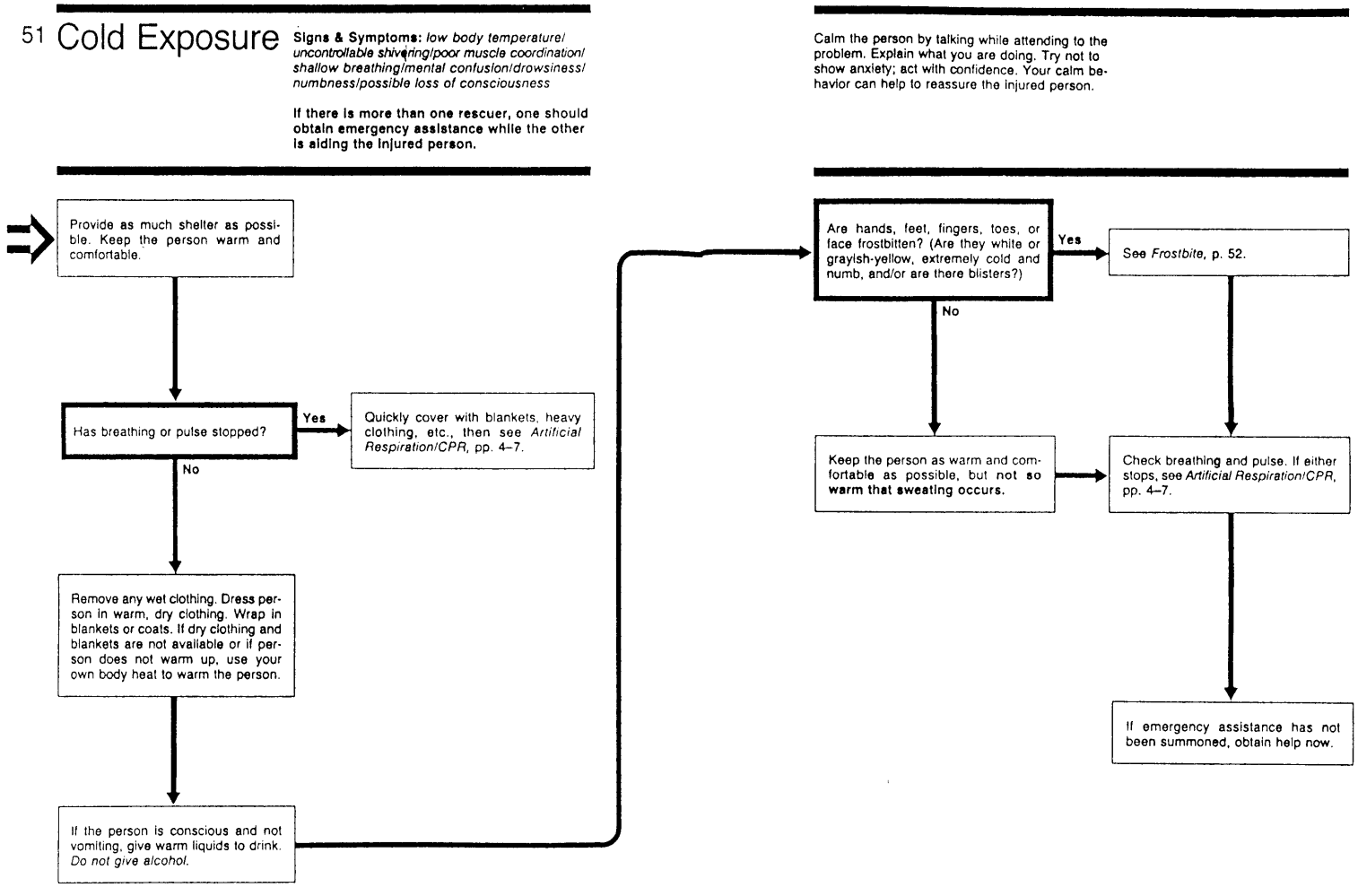

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Table 5.3 Threshold Limit Values Work/Warmup Schedule for Four-hour Shift

Air Temperature Sunny Sky		No Noticeable Wind		5 mph Wind		10 mph Wind		15 mph Wind		20 mph Wind	
°C (Approx.)	°F (Approx.)	Max. Work Period	No. of Breaks	Max. Work Period	No. of Breaks	Max. Work Period	No. of Breaks	Max. Work Period	No. of Breaks	Max. Work Period	No. of Breaks
-26 to -28	-15 to -19	(Norm. breaks)	1	(Norm. breaks)	1	75 min	2	55 min	3	40 min	4
-29 to -31	-20 to -24	(Norm. breaks)	1	75 min	2	55 min	3	40 min	4	30 min	5
-32 to -34	-25 to -29	75 min	2	55 min	3	40 min	4	30 min	5	Nonemergency work should cease	
-35 to -37	-30 to -34	55 min	3	40 min	4	30 min	5	Nonemergency work should cease		Nonemergency work should cease	
-38 to -39	-35 to -39	40 min	4	30 min	5	Nonemergency work should cease		Nonemergency work should cease		Nonemergency work should cease	
-40 to -42	-40 to -44	30 min	5	Nonemergency work should cease		Nonemergency work should cease		Nonemergency work should cease			
-43 and below	-45 and below	Nonemergency work should cease		Nonemergency work should cease		Nonemergency work should cease		Nonemergency work should cease		Nonemergency work should cease	

1. Schedule applies to moderate to heavy work activity with warmup breaks of ten (10) minutes in a warm location. For light to moderate work (limited physical movement): apply the schedule one step lower. For example, at -35 °C (-30 °F) with no noticeable wind, a worker at a job with little physical movement should have a maximum work period of 55 minutes with three breaks in a 4-hour period.
2. The following is suggested as a guide for estimating wind velocity if accurate information is not available: 5 mph: light flag moves; 10 mph: light flag fully extended; 15 mph: raises newspaper sheet; 20 mph: blowing and drifting snow.
3. If only the wind chill cooling rate is available, a rough rule of thumb for applying it rather than the temperature and wind velocity factors given above would be: (1) special warmup breaks should be initiated at a wind chill cooling rate of about 1,750 W/m2; (2) all nonemergency work should have ceased at or below a wind chill of 2,250 W/m2. In general, the warmup schedule provided above slightly under-compensates for the wind at the warmer temperatures, assuming acclimatization and clothing appropriate for winter work. On the other hand, the chart slightly over-compensates for the actual temperatures in the colder ranges, since windy conditions rarely prevail at extremely low temperatures.
4. TLVs apply only for workers in dry clothing.

TLVs recommended for properly clothed workers for periods of work at temperatures below freezing are shown in Table 5.3.

Special protection of the hands is required to maintain manual dexterity for the prevention of accidents:

- If fine work is to be performed with bare hands for more than 10 to 20 minutes in an environment below 16°C (60.8°F), special provisions shall be established for keeping the workers' hands warm. Metal handles of tools and control bars shall be covered by thermal insulating material at temperatures below -1°C (30.2°F).
- If the air temperature falls below 16°C (60.8°F) for sedentary, 4°C (39.2°F) for light, or -7°C (19.4°F) for moderate work, and fine manual dexterity is not required, then gloves shall be worn.

To prevent contact frostbite, the workers shall wear anti-contact gloves.

- When cold surfaces below -7°C (19.4°F) are within reach, a warning shall be given to each worker by the supervisor to prevent inadvertent contact by bare skin.
- If the air temperature is -17.5°C (0°F) or less, the hands shall be protected by mittens. Machine controls and tools for use in cold conditions shall be designed so that they can be handled without removing the mittens.

Provisions for additional total body protection are required if work is performed in an environment at or below 4°C (39.2°F). The workers shall wear cold protective clothing appropriate for the level of cold and physical activity:

- If the air velocity at the job site is increased by wind, draft, or artificial ventilating equipment, the cooling effect of the wind shall be reduced by shielding the work area or by wearing an easily removable windbreak garment. If only light work is involved and if the clothing on the worker may become wet on the job site, the outer layer of the clothing in use may be of a type impermeable to water. With more severe work under such conditions, the outer layer shall be water repellent, and the outerwear shall be changed as it becomes wetted. The outer garments shall include provisions for easy ventilation in order to prevent wetting of inner layers by sweat. If work is done at normal temperatures or in a hot environment before entering the cold area, the employee shall make sure that clothing is not wet as a consequence of sweating. If clothing is wet, the employee shall change into dry clothes before entering the cold area. The workers shall change socks and any removable felt insoles at regular daily intervals or use vapor barrier boots. The optimal frequency of change shall be determined empirically and will vary individually and according to the type of shoe worn and how much the individual's feet sweat.
- If exposed areas of the body cannot be protected sufficiently to prevent sensation of excessive cold or frostbite, protective items shall be supplied in auxiliary heated versions.

- If the available clothing does not give adequate protection to prevent hypothermia or frostbite, work shall be modified or suspended until adequate clothing is made available or until weather conditions improve.
- Workers handling evaporative liquid (i.e., decontamination solvents) at air temperatures below 4°C (39.2°F) shall take special precautions to avoid soaking of clothes or gloves with the liquids because of the added danger of cold injury due to evaporative cooling.

SECTION 6

EMERGENCY RESPONSE PLAN

All hazardous waste site activities present a degree of risk to on-site personnel. During routine operations, risk is minimized by establishing good work practices, staying alert, and using proper PPE. Unpredictable events such as physical injury, chemical exposure, or fire may occur and must be anticipated. On-site employees involved with the field investigation must participate in Red Cross or equivalent courses and be currently certified in first-aid and CPR in order to more effectively handle physical and medical emergencies that may arise in the field.

6.1 GUIDELINES FOR PRE-EMERGENCY PLANNING AND TRAINING

Employees must read this health and safety plan and must familiarize themselves with the information in this chapter. Prior to project initiation, the SHSO will conduct a meeting with the field team members to review the provisions of the safety plan and to review the emergency response plan. Employees will be required to have a copy of the emergency contacts and telephone numbers immediately accessible on-site and to know the route to the base hospital. A map is attached as Figure 6.1. Figure 6.2 shows the route to the Midwest City Hospital.

6.2 EMERGENCY RECOGNITION AND PREVENTION

Emergency conditions are considered to exist if the following situations occur:

- Any member of the field crew is involved in an accident or experiences any adverse effects or symptoms of exposure while on site.
- A condition is discovered that suggests the existence of a situation more hazardous than anticipated.
- Concentrations of flammable vapors reach or exceed 10 percent of the lower explosive limit (LEL).
- A potential for toxic chemical/gas exposure exists.
- A fire or explosion hazard exists.
- Physical injury and medical emergencies have occurred.
- A vehicle accident occurs.

Some ways of preventing emergency situations are listed below.

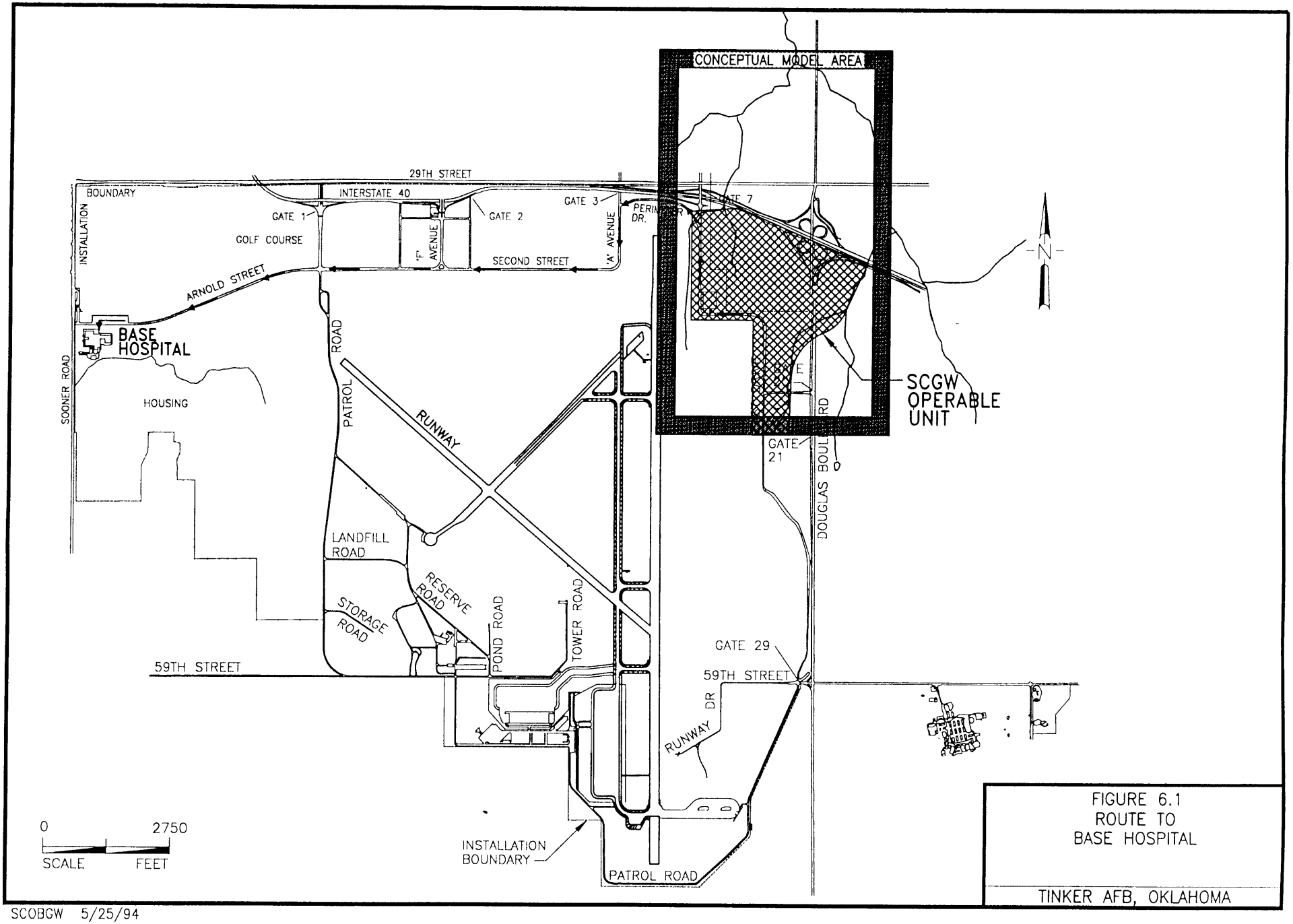

FIGURE 6.1
ROUTE TO
BASE HOSPITAL

TINKER AFB, OKLAHOMA

SCOBGW 5/25/94

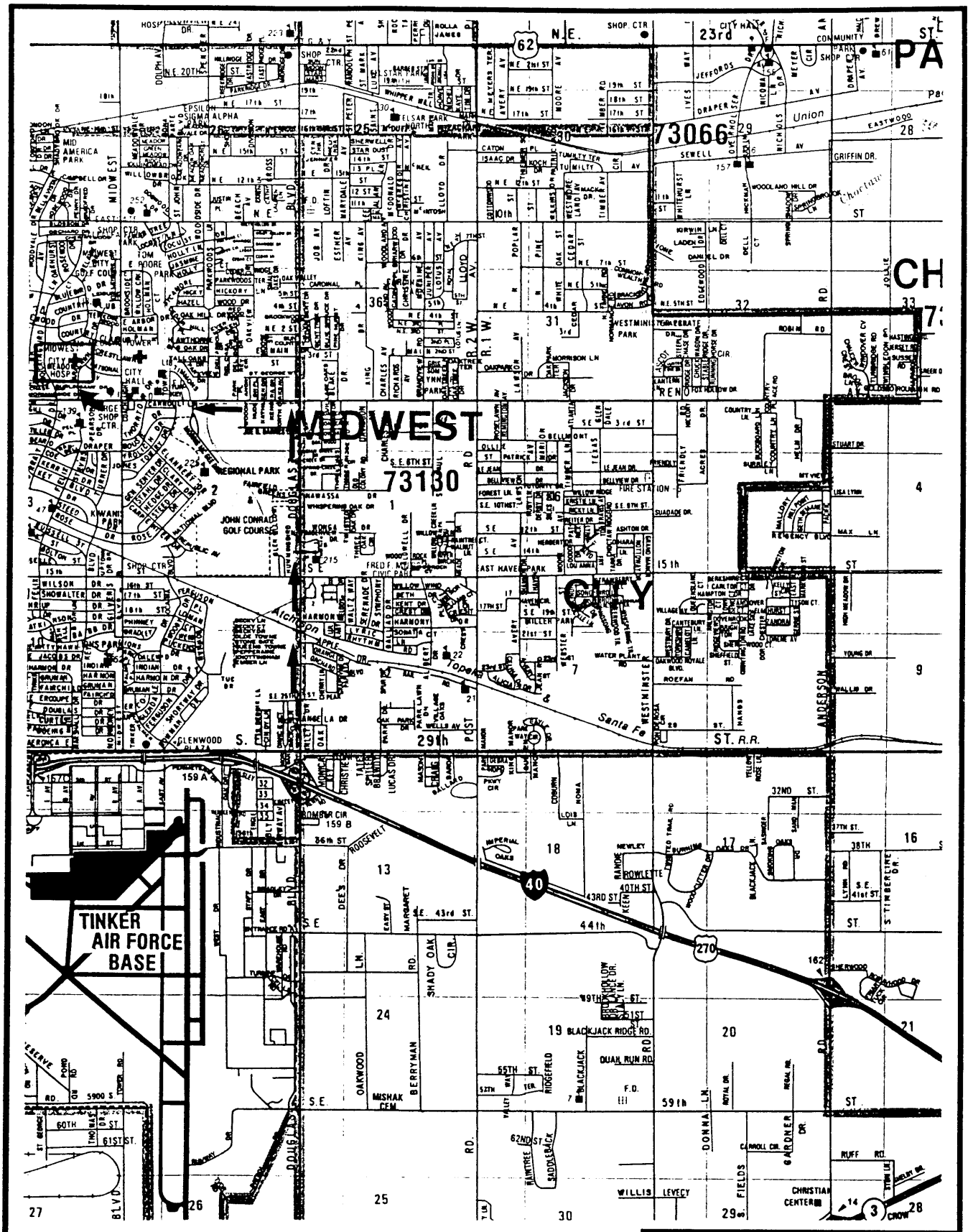

FIGURE 6.2
ROUTE TO
MIDWEST CITY
HOSPITAL

TINKER AFB, OKLAHOMA

- On-site workers will act as safety backup to each other. Off-site personnel provide emergency assistance.
- Hand signals will be developed for communications when personnel are wearing respiratory protection (see Section 9).
- All field crew members should make use of all of their senses to alert themselves to potentially dangerous situations which they should avoid (e.g., the presence of strong and irritating or nauseating odors).
- Personnel will practice unfamiliar operations prior to performing field procedures.
- No field vehicles will be allowed off the main roads or in contaminated areas.
- Work areas and decontamination procedures must be established prior to entering exclusion zones.
- Field crew members will be familiar with the physical characteristics of investigations, including:
  - Wind direction in relation to contamination zones;
  - Accessibility to associates, equipment, utilities, and vehicles;
  - Communications;
  - Hot zones (areas of known or suspected contamination);
  - Site access; and
  - Nearest water sources.

In the event that a member of the field crew experiences any adverse effects or symptoms of exposure while on the scene or organic or combustible vapors exceed the action limits, fellow field crew members in the area will immediately halt work and act according to instructions provided by the SHSO. In addition, if air monitoring devices fail, field crews working in the area will immediately evacuate the premises until equipment is repaired or replaced.

The discovery of any condition that would suggest the existence of a situation more hazardous than anticipated will result in the evacuation of the field team and reevaluation of the hazard and the level of protection required.

In the event an accident occurs, the field supervisor or the SHSO will complete the appropriate accident report form. A copy of the accident report form is included in Appendix A. Follow-up action should be taken to correct the situation that caused the accident.

In the event that a release occurs, the team members and field team leader will respond appropriately, as described in the Spill Response Plan (Appendix C). Appendix D contains instructions and guidance from Headquarters Oklahoma City Air Logistics Center regarding procedures for requesting emergency care, pass and ID procedures, vertical clearance requirements, and a fire prevention briefing.

6.3 DECONTAMINATION AND EMERGENCY MEDICAL TREATMENT OF PERSONNEL DURING AN EMERGENCY

All base telephone numbers start with '73.' When calling from a base telephone, '73' should not be dialed. The trailer telephone is NOT a base telephone; therefore, the entire telephone number must be dialed.

6.3.3 Procedures During Fire or Explosion or Environmental Incident

Evacuate all personnel to a safe location upwind of the incident and contact the Fire Department. The fire department can be reached at 734-7964 (off base) or 47964 (on base).

6.3.4 Procedures For Emergency Medical Treatment And First Aid

In the event that emergency first-aid procedures are required, the base hospital will provide emergency medical treatment and the base fire department will provide 24-hour ambulance service. The SHSO will prepare an emergency action checklist(s) to be kept readily available to provide appropriate emergency phone calls/actions at the field site for at least the following situations:

- Toxic chemical/vapor exposure;
- Fire/explosion;
- Physical injury/medical emergency (including heat and cold injury, heart attack, electrocution, etc.);
- Security (assault, robbery, theft, etc.); and
- Vehicle accidents.

6.3.4.1 Injury From Chemical Exposure

If it is suspected that a person has suffered from chemical exposure, the following procedures will be undertaken:

- Skin contact - Flush with water. Remove clothing, if necessary. Wash/rinse affected area for at least 15 minutes. Decontaminate any exposed areas and call the base hospital at 734-8249 (off base) or 48249 (on base).
- Inhalation - Move person away from area. Administer CPR as needed. Decontaminate any exposed areas and call the base hospital at 734-8249 (off base) or 48249 (on base).
- Ingestion - Decontaminate any exposed areas, do not induce vomiting, and contact the base hospital at 734-8249 (off base) or 48249 (on base).
- Eye contact - Irrigate with water for at least 15 minutes, decontaminate any exposed areas, and call the base hospital at 734-8249 (off base) or 48249 (on base).
- For trauma injuries, victims will be transported to the base hospital.

6.3.4.2 Personal Injury

In the event of personal injury:

- Field team members trained in first aid can administer treatment to an injured worker.
- The victim should be transported to the base hospital. If necessary, an ambulance should be called to transport the victim. The Fire Department dispatches ambulances. Call 734-7964 (off base) or 47964 (on base).
- The SHSO or the employee's field supervisor is responsible for the completion of the appropriate accident report form.

6.4 EMERGENCY CONTACTS

In the event of any situation or unplanned occurrence requiring assistance, the appropriate contact(s) should be made from the list below. If practical, contact should be made with the site point of contact or site emergency personnel who will then contact the appropriate response teams.

Tinker AFB Emergency number	117
Fire Department	405/734-7964
Base Hospital	405/734-8249
Ambulance	405/734-7964
Midwest City Regional Hospital	405/737-4411
ES Project Manager - Dr. John Yu	512/719-6000
ES RI Manager and Field Operations Leader - John Osweiler, P.G.	405/720-0785
ES Office Health and Safety Manager - Randy Palachek	512/719-6000
ES Site Health and Safety Officer - Marc Harder, P.G.	512/719-6000
Poison Control Center	800/492-2414
National Response Center	800/424-8802
Tinker AFB Project Manager - John Schroeder, P.E.	405/736-2941
Tinker AFB Contracting Officer - Gordon Mohon	405/739-3367

6.5 ACCIDENT REPORTING REQUIREMENTS

All accidents, incidents, and injuries must be reported to the ES SHSO immediately. It will be the responsibility of the SHSO to report these occurrences to the Office Health and Safety Manager. All injuries or damage to government property must be reported to Ground Safety SEG at 739-3263.

SECTION 7

LEVELS OF PROTECTION AND PERSONAL PROTECTIVE EQUIPMENT REQUIRED FOR SITE ACTIVITIES

7.1 PERSONAL PROTECTIVE EQUIPMENT

The personal protection level prescribed for the field investigation is modified Level D with a contingency for the use of OSHA Level B or C. The requirements for respiratory protection under various circumstances and for different activities are described in Section 8.

As described in Section 8, ambient air monitoring of organic gases/vapors with photoionization detectors and colorimetric tubes and inorganic contaminants with colorimetric tubes and a MiniRam, if necessary, will be used to select the appropriate level of PPE. Table 8.2 lists the action levels for contaminants of concern and gives the action levels for each OSHA level of PPE.

Engineering-Science follows a Respiratory Protection Program. The objective of the program is to provide ES field personnel with sufficient information and guidance to adequately protect themselves from potential inhalation hazards during hazardous waste or industrial field operations (ES, 1991).

All on-site personnel shall have NIOSH-approved full-face, air-purifying respirators equipped with combination organic/HEPA cartridges immediately available in the event that Level C respiratory protection is required for protection against particulates (such as chromium), or some identified volatile organics.

Level C respiratory protection CANNOT be used in the presence of unknown vapors on this project due to the presence of volatile or semivolatile compounds with odor thresholds higher than the exposure limits. As shown in Table 5.1, some compounds do not have established exposure limits and/or odor thresholds. Therefore, unless all of these compounds can be excluded using air monitoring, Level C respiratory protection cannot be used in the presence of unknown organic vapors.

The levels of respiratory protection specified for this project are as follow:

D OSHA Level D (modified) - For use where exposure to chemical vapors or particulates is not anticipated.

C OSHA Level C - Full-face air-purifying respirator (APR) equipped with combination organic vapor/HEPA cartridges. For use where organic vapor is known and/or particulate protection.

B OSHA Level B - Positive-pressure, full-facepiece self-contained breathing apparatus (SCBA) or supplied air respirator (National Institute of Occupational Safety and Health [NIOSH]/Mine Safety and Health Administration [MSHA] approved).

In all cases, the SHSO has the authority to stop work and allow the crew and project management staff time to reevaluate the working situation and take appropriate actions. The office health and safety manager and the SHSO must be notified prior to use of Level B equipment.

The PPE needed to comply with the various levels of protection is detailed below.

7.2 LEVELS OF PROTECTION

7.2.1 Level D

Level D (no respiratory protection) may be used when the workplace atmosphere contains no potential respiratory hazard and when work functions do not involve splashes, immersion, or the potential for unexpected inhalation of or contact with hazardous levels of any chemicals.

All field work conducted at Tinker AFB will be conducted in Level D-modified, unless air monitoring results require a greater level of protection. That is, some protective clothing will be worn. Depending on the nature of the work being performed, protective clothing may consist of Tyvek™ suits, protective gloves, and other protective clothing as described below. Level D-modified consists of:

- Tyvek or similar disposable coverall (optional): For use during any field activity which requires that personnel come into contact with soil or water;
- Inner gloves (latex or nitrile) as determined: For use during any field activity which requires that personnel come into contact with soil or water;
- Outer gloves such as nitrile or neoprene (optional): For use during any field activity which requires that personnel come into contact with soil and water;
- Steel toed, steel shank boots (chemical-resistance is optional): Mandatory for all field investigation activities;
- Safety glasses: For use during all drilling and sampling activities;
- Hard hat (when working around heavy equipment): Mandatory for all personnel working behind an operating rig; and
- Additional items may be required in specific locations or tasks.

7.2.2 Level C

Level C protection (APR) may be worn only when the criteria for using APR are met and a minimal level of skin protection is needed. Level C includes:

- APR, full-face, cartridge-equipped (NIOSH/MSHA approved);
- Tyvek or similar disposable coverall (optional);

- Saranex® or similar coverall (for areas with the potential for contact with hazardous liquids);
- Steel toed, steel shank boots;
- Disposable latex boot covers or chemical-resistant boots with steel toe and shank (optional);
- Inner chemical-resistant disposable gloves (latex or nitrile);
- Outer chemical-resistant gloves (neoprene or nitrile);
- Hard hat (when working around heavy equipment); and
- Additional items which may be required for specific locations or tasks.

7.2.3 Level B

Level B protection should be worn when the highest level of respiratory protection is needed for hazardous compounds, and a moderate level of skin protection is required. Level B consists of:

- Positive-pressure, full-facepiece SCBA or supplied-air respirator (NIOSH/MSHA approved);
- Saranex, or similar, outer coveralls with hood
- Inner chemical-resistant disposable gloves (nitrile or latex);
- Outer chemical-resistant gloves (neoprene or nitrile);
- Steel toed, steel shank boots with disposable latex boot covers or chemical-resistant boots with steel toe and shank;
- Hard hat (when working around heavy equipment); and
- Additional items which may be required in specific locations or tasks.

7.3 EQUIPMENT NEEDS

Each field team shall have the following items readily available:

- Copy of site health and safety plan;
- Air monitoring instruments (as specified in Section 8);
- First aid kit;
- Adequate supply of personal protective equipment;
- Portable eye wash stations;
- Decontamination supplies;
- Potable water; and
- Fire extinguishers.

SECTION 8

FREQUENCY AND TYPES OF AIR MONITORING

The purpose of air monitoring is to identify and quantify airborne contaminants in order to determine the level of respiratory protection needed. Periodic air monitoring will be conducted to identify the presence of organic vapors and other hazardous conditions. All monitoring equipment will be calibrated according to manufacturer-recommended procedures and frequencies.

Daily entries into the field log book should include information such as description of field work being conducted, any changes in the operation, name of personnel working at the site, types of air monitoring equipment being used, calibration of equipment, air monitoring results, level of PPE being worn, and a description of any unusual occurrences or physical complaints.

8.1 TYPES OF AIR MONITORING

Air monitoring requirements will be dependent on the specific operation, location requirements, and pre-entry air data concerning the particular area under investigation. Air monitoring will be conducted to provide real-time warning of exposure to contaminants and also to provide a characterization of personal exposure for this work. Direct-reading instruments will be used to detect flammable or explosive atmospheres and volatile organics, as appropriate.

The following paragraphs provide brief descriptions of these methods. Monitoring methods to detect exposure for specific contaminants must take into account the expected concentrations and species of contaminants, and the limitations and advantages of available methods.

8.1.1 Organic Vapor Monitoring

Organic vapor monitoring will be conducted periodically or continuously, when necessary during the field investigation activities at Tinker AFB. The SHSO (or designee) will be responsible for performing ambient air quality monitoring with a direct-reading, organic vapor detector such as an HNU® photoionization detector (PID) or an organic vapor analyzer (OVA) flame ionization detector (FID).

The HNU, or OVA, will be used as the initial indicator of possible exposure to organic vapors. Both benzene and vinyl chloride have very low action levels (1 pm each). If the HNU/OVA readings show that the concentration of organic vapors in the breathing zone exceeds 1 ppm above background, benzene and vinyl chloride colorimetric tubes will be used to determine whether these compounds are present.

Section 8.3.2 explains the procedures to follow when HNU readings exceed 1 ppm in the breathing zone.

Colorimetric indicator tubes will be available on site for detection of vinyl chloride and benzene. Colorimetric tubes for the other contaminants of concern may be obtained from a local supplier, if needed.

Once it has been determined that the levels of organic vapor are at or above action levels, continual monitoring will be initiated. Monitoring will take place at a frequency and pattern needed to represent the levels of exposure of all the field team members. Where exposures are at or above the TWA, monitoring will assure the adequacy of respiratory selection and the effectiveness of engineering controls. OSHA requires that personal air monitoring take place at least once every four months when levels for vinyl chloride are greater than action levels and once per month when levels are greater than PEL (29 CFR 1910.1017).

8.1.2 Combustible Gas/Explosive Environment Monitoring

An explosivity meter (oxygen/combustible gas meter), HMX 271 combustible gas indicator, will be used during initial entries into areas where flammable materials or fuel may occur and during excavation and drilling operations for measuring combustible gas levels. The instrument is portable, lightweight, fully automatic, and provides characteristic warning signals when unacceptable levels of combustible gas are detected. The instrument can detect combustible concentrations up to the lower explosive limit (LEL).

NIOSH has established the following guidelines concerning working in an explosive environment:

1. If explosivity readings are detected between 10-25 percent LEL, then work activities in the area should be limited to those that do not generate sparks.
2. If the explosivity readings on the combustible gas indicator is above 25 percent, operations will terminate and the onsite area must be immediately evacuated until appropriate action can be taken to eliminate the hazard.

These guidelines will be followed during the monitoring for explosive environments. Once the site has been evacuated, the resumption of onsite activities will not occur until the SHSO has consulted with personnel experienced in fire or explosion hazards.

8.1.4 Particulate Monitoring

In areas where exposure to particulates may be of concern, particulate monitoring may be conducted using a MiniRam aerosol monitor. If particulates occur above the established exposure limit for chromium, the field crew will implement proper engineering controls (such as dust suppression) or select appropriate protective equipment.

Once it has been determined that the levels of particulates are at or above action levels, continuous monitoring will be initiated. Monitoring will take place at

a frequency and pattern needed to represent the levels of exposure of all members of the field team. Where exposures are above the PEL, monitoring will assure the adequacy of respiratory selection and the effectiveness of engineering controls. OSHA requires personal air monitoring at least once every six months for levels at or above action levels, and every four months for levels above PELs (29 CFR 1910.1025, 1027).

8.1.5 Personal Exposure Monitoring

The majority of the field activities will be conducted off base where contamination is believed to be minor. If contaminants are encountered and measured by the HNU above action levels, personal air sampling will be conducted. Sampling may be conducted using personal sampling pumps fitted with the appropriate sampling media or by using passive organic vapor badges. Samples will be analyzed by a laboratory accredited by the American Industrial Hygiene Association and will be submitted using proper chain-of-custody procedures. The samples will be analyzed for vinyl chloride and halogenated hydrocarbons (NIOSH methods 1007 and 1003, respectively) to establish that permissible exposure limits (PELs) have not been exceeded. Sampling pumps worn during drilling will also be analyzed for chromium and lead.

The personal air sampling will be performed during source air testing and/or during drilling, as determined by the SHSO. Full-shift (8-hour) breathing zone samples will be collected whenever possible. The individuals selected for personal air monitoring will be those expected to have the greatest risk of exposure, or those experiencing exposures that are typical of ongoing activities.

8.2 AIR MONITORING PROGRAM

8.2.1 Air Monitoring Methods

The various contaminants can be detected and monitored using different methods and equipment. The monitoring methods applicable for each compound are summarized in Table 8.1.

8.2.2 Action Levels

The action levels for implementing B, C, and D levels of protection are summarized in Table 8.2, where the contaminant concentration ranges for each contaminant of concern or monitored parameter and each level of protection are listed.

Alternately, contaminant concentrations can be controlled using engineering controls (ventilation, wetting, etc.) to allow the use of a lower level of protection, provided that monitoring shows that the concentrations have been reduced to the appropriate ranges.

8.2.3 Air Monitoring Requirements for Field Activities

In this section, the air monitoring requirements for each field activity are described.

Table 8.1 Air Monitoring Methods

Contaminant	Detection Method
Benzene	PID or FID and colorimetric tubes
Chlorobenzene	PID or FID
Cadmium	Miniram
Chromium	Miniram
1,2-Dichlorobenzene	PID or FID
Dichloroethene	PID or FID
Ethyl benzene	PID or FID
Lead	Miniram
Tetrachloroethene	PID or FID
Toluene	PID or FID
Trichloroethene	PID or FID
Vinyl chloride	PID or FID and colorimetric tubes
Xylenes	PID or FID
Explosive Vapor/Oxygen Deficient Atmosphere	Combustible gas/ O_2 meter

Notes:

PID = photoionization detector, such as HNU®
FID = flame ionization detector, such as organic vapor analyzer (OVA)

Table 8.2
Action Levels

Level B	
Contaminant	**Level**
Benzene	> 1 ppm
Chromium	$\geq$ 250 mg/m^3
Dichloroethene	$\geq$ 1,000 ppm and < 4,000 ppm
Chlorobenzene	$\leq$ 500 ppm and $\leq$ 2,400 ppm
Vinyl Chloride	$\geq$ 1 ppm
1,2-Dichlorobenzene	$\geq$ 1,000 ppm
Tetrachloroethene	$\geq$ 25 ppm and $\leq$ 500 ppm
Trichloroethene	$\geq$ 50 ppm and $\leq$ 1,000 ppm

Level C	
Contaminant	**Level**
Chromium	> 0.5 mg/m^3 and < 250 mg/m^3
Dichloroethene	> 200 ppm and < 1,000 ppm
Chlorobenzene	> 10 ppm and < 500 ppm
1,2-Dichlorobenzene	> 50 ppm and < 1,000 ppm
Trichloroethene	< 50 ppm
Organic Vapors	< 5 ppm with < 1 ppm Vinyl Chloride < 10 ppm with < 1 ppm Vinyl Chloride and < 5 ppm Phenol

Level D	
Contaminant	**Level**
Benzene	< 1 ppm
Chlorobenzene	< 10 ppm
Chromium	< 0.5 mg/m^3
Dichloroethene	< 200 ppm
Ethyl benzene	<100 ppm
Vinyl Chloride	< 1 ppm
1,2-Dichlorobenzene	< 50 ppm
Tetrachloroethene	< 25 ppm
Toluene	<50 ppm
Trichloroethene	< 50 ppm
Xylenes	<100 ppm

Explosive Vapors and Oxygen Deficient Atmospheres	
Contaminant	**Level to Stop Work**
Combustible Vapors	> 10% LEL
Oxygen	< 19.5% or > 23.5%

8.2.3.1 Ambient Air Monitoring

Monitoring of organic vapors will be conducted during ambient air monitoring, unless there is dust, in which case particulate monitoring will also be performed. Organic vapor monitoring will include the use of a PID or FID and colorimetric tubes when necessary. Ambient air monitoring will be performed prior to the start of work, periodically during work, and as working conditions change. If the PID or FID reading in the breathing zone is greater than 1.0 ppm, benzene and vinyl chloride tubes should be used. Particulate monitoring, if necessary, will be done prior to the start of work and continuously during work, using the MiniRam®.

8.2.3.2 Air Monitoring During Drilling of Soil Borings and Continuous Cores

Air monitoring during drilling of soil borings and continuous cores will consist of organic vapor monitoring, explosive vapor monitoring, and, if dust occurs, particulate monitoring. Colorimetric tubes will be used to identify organic vapors when necessary.

8.2.3.3 Air Monitoring During Sediment Sampling

Air monitoring during stream sediment sampling will consist of organic vapor monitoring only.

8.2.3.4 Air Monitoring During Groundwater Sampling and Pump Tests

Air monitoring during groundwater sampling and pump tests will consist of organic vapor monitoring only, using a PID or FID. Organic vapor monitoring will be performed prior to the start of work, periodically during work, and as working conditions change. Colorimetric tubes will be used to identify organic vapors when necessary.

8.3 AIR MONITORING EQUIPMENT CALIBRATION AND MAINTENANCE

The following sections describe the equipment used in the field to measure specified parameters. Procedures for equipment calibration, maintenance and decontamination are summarized on Table 8.3.

Air monitoring measurements may be made using the following equipment:

- HNU photoionization detector (PID)
- Organic vapor analyzer (OVA)
- Sensidyne one-stroke pump and colorimetric tubes
- HMX271 combustible gas indicator.

Before use, field monitoring instruments will be calibrated on a schedule according to the manufacturer's specifications. A copy of the operations manual will be kept with all field monitoring equipment. The operator must understand the limitations of each instrument and the possible sources of error. Furthermore, the operator must ensure that the equipment is in good working order and functioning

Table 8.3 Calibration Methods and Frequency
Tinker AFB SCGW RI/FS

Parameter	Equipment	Calibration	Source of Calibration Standards	Equipment Maintenance	Equipment Decontamination
Volatile organic compounds (VOC)	Photoionization detector (PID).	Daily according to manufacturer's instructions with ambient air (considered 0 mg/L) and isobutylene gas (100 mg/L).	Commercially available, premixed, in cylinders.	Avoid prolonged use in humid environments; keep probe away from dirt or free water; recharge battery.	Replace instrument filter; clean lamp.
VOC	OVA.	Daily, and every 2-3 hours during use, methane in air.	Scott specialty gases.	Charge batteries, keep probe out of liquids.	Not applicable.
Explosive gases	Combustible gas indicator.	Daily with known gas and concentration; daily testing in known explosive environment (gas tank) and zero adjustment in clean environment.	Commercially available, battery.	Keep inlet away from dirt or free liquids, recharge battery.	Not applicable.

properly. All calibration activities will be noted in the field logbook and the calibration logbook.

8.3.1 HNU Photoionization Detector and Organic Vapor Analyzer

Monitoring for total organic vapors and gases in the field will be conducted using the HNU photoionization detector or the OVA. The HNU measures up to 2,000 parts per million (ppm) organic vapors in the air and will be used for various field screening techniques.

During drilling of soil and monitoring well borings and monitoring well installation, the PID will be used periodically to monitor the breathing zone, drill cuttings, borehole and undisturbed core samples. Headspace analyses of soil samples retrieved with a core sampler during drilling will also be tested with the HNU or OVA. All readings made with the HNU or OVA will be recorded either in the field logbook or directly on the field boring logs.

During well development, groundwater sampling, and surface soil sampling, the HNU or OVA will be used to monitor the breathing zone, and readings will be recorded in the field logbook. Furthermore, immediately after the monitoring well cap is removed, a reading will be taken inside the top of casing. Prior to use of the HNU or OVA for air monitoring, personnel will be thoroughly familiar with contaminant-specific action levels defined in Table 8.2. The HNU is very sensitive to moisture so it must be kept as dry as possible.

The HNU photoionization detector or OVA will be calibrated according to the user's manual at least once a day prior to use in the field. The standard calibration gas for the HNU is isobutylene, which may be obtained in canisters from an environmental sampling equipment supplier.

8.3.2 Sensidyne One-Stroke Pump and Tubes

If the concentration of organic vapors in the breathing zone exceeds 1 ppm above background, benzene and vinyl chloride Sensidyne tubes will be used to determine whether these compounds are present. These two compounds have the lowest permissible exposure limit (PEL) of all suspected contaminants on site. Sensidyne tubes are compound specific and may be used to determine if the compound is present and to quantify the concentration. If needed, Sensidyne tubes will be used during drilling activities, monitoring well installations, subsurface soil sampling, groundwater sampling, and the geophysical surveys. The frequency of ambient air monitoring is listed in Section 8.2.3.

The tube is physically broken open at one end, and ambient air is manually drawn through the system to obtain a direct reading. Sensidyne tubes do not require calibration.

Each Sensidyne tube contains a reagent system designed to undergo a chemical reaction with a particular substance. Since chemicals and chemical reagents are not stable indefinitely, each box of detector tubes is stamped with an expiration date. The tubes are suitable for use through the last day of the month of expiration.

Tubes used beyond the expiration date cannot be relied upon to give accurate results.

To guarantee the validity of the tube expiration date, Sensidyne tubes should always be stored in the original package at room temperature. A note on the package indicates a maximum storage temperature of 25°C (77°F). Excessively low (less than 35°F) or high (greater than 77°F) temperatures during storage will be avoided, and the tubes will not be subjected to light for prolonged periods.

Detector tubes are tested according to NIOSH method TCA/A-012, "Certification Requirements for Gas Detector Tube Units," for the Safety Equipment Institute certification program. Furthermore, each manufacturer's detector tubes are tested as a unit by an independent third party laboratory accredited by the American Industrial Hygiene Association (AIHA).

The Sensidyne one-stroke pump and tubes require no general maintenance.

8.3.3 HMX271 Combustible Gas Indicator

The HMX271 combustible gas indicator will be used to measure the lower explosive limit (LEL) in work areas. The LEL of a combustible gas or vapor is the lowest concentration by volume in air which will explode when there is an available ignition source. During field activities that can potentially generate sparks, such as drilling or welding, the breathing zone and the air in and around the borehole or well will be periodically monitored with the HMX271 combustible gas indicator. Furthermore, during field activities around enclosed spaces the breathing zone will also be monitored for the presence of combustible gases and vapors.

The HMX271 combustible gas indicator takes continuous and simultaneous measurement of combustible gases, oxygen levels, and hydrogen sulfide concentrations. The HMX271 should be calibrated with pentane according to the user's manual prior to field work each day.

If the HMX271 is used to measure hydrogen sulfide, it will first be calibrated with the appropriate calibration gas.

In oxygen enriched and deficient atmospheres, erroneous determinations of combustible gas can occur. In addition, long continuous use at high LEL concentrations (50 to 100%) may cause damage to the LEL detector.

The HMX271 combustible gas indicator will be maintained in the field by wiping the unit clean after every use, storing the unit in a safe protected case, and recharging the battery on a daily basis or as use dictates.

SECTION 9

SITE CONTROL MEASURES

The following site control measures will be followed in order to minimize potential contamination of workers, and to control access to the exclusion zones. Site control involves the physical arrangement and control of the operation zones and the methods for removing contaminants from workers and equipment. The first aspect, site organization, is discussed in this section. The second aspect, decontamination, is considered in the next section. Section 7 addresses the levels of PPE required.

9.1 SITE ORGANIZATION/OPERATION ZONES

When necessary, as determined by the SHSO or designee, the following operation zones will be established on the site:

- Exclusion Zone
- Contamination Reduction Zone
- Support Zone.

The field crew will establish a single station decontamination area. The SHSO will be responsible for establishing the size and distance between zones at the site or around the site feature. Considerable judgement is required to assure that safe working distances for each zone are balanced against practical work considerations.

9.1.1 Exclusion Zone (EZ)

The EZ includes the areas where active field investigations take place. Within the EZ, prescribed levels of PPE will be worn by all personnel. The hotline, or EZ boundary, will be established based upon daily site activities or through visual observations or general air monitoring procedures. The hotline may be readjusted based upon subsequent observations. This boundary will be physically secured and posted or well-defined by physical and geographic boundaries. Hard hats must be worn in the EZ during drilling operations.

9.1.2 Contamination Reduction Zone (CRZ)

The contamination reduction zone (CRZ) is located between the EZ and the support zone. This zone provides an area to prevent or reduce the transfer of hazardous materials which may have been picked up by personnel or equipment leaving the EZ. The organization of the CRZ and the control of decontamination

operations are described in Section 10. The CRZ is not necessary during level D operations and most level C operations.

9.1.3 Support Zone (SZ)

The support zone is the outermost area of the site and is considered an uncontaminated or clean area. The support zone for this project will be located upwind of the exclusion zone under investigation whenever possible. The support zone contains the command vehicle for field operations equipped with first-aid kits, decontamination materials, and other investigation and cleanup support supplies. Normal work clothes are appropriate apparel within this zone; potentially contaminated personnel, clothing, equipment, etc., are not permitted. Since Tinker AFB field investigation activities may be conducted during the winter months, special types of PPE and other safety equipment susceptible to freezing (e.g., eye wash and decontamination solutions) will be stored in a heated vehicle.

9.2 SITE SECURITY

Site security will be enforced by the SHSO or designee, who will ensure that only authorized personnel are allowed in the work area and that entry personnel have the required level of PPE, are trained under the requirements of 29 CFR 1910.120, and are on a current medical monitoring program. Site security is necessary to prevent exposure of unauthorized, unprotected individuals in the work area.

9.3 SITE COMMUNICATION

Internal site communication is necessary to alert field team members in the EZ and CRZ of emergency conditions, to convey safety information, and to communicate changes or clarification in the work to be performed. When verbal communication is not possible, field team members will use prearranged hand signals. If at any time communication is broken, the field team will re-group and remedies will be implemented. Table 9.1 lists internal emergency communications signals.

9.4 SAFE WORK PRACTICES

To ensure a strong safety awareness program during the field activities, personnel will receive adequate training, this plan will be communicated to the employees, and standing work orders will be developed and communicated to the employees. Sample standing orders for personnel entering the CRZ and the EZ are as follows:

- No smoking, eating, drinking, or chewing of tobacco or gum;
- No matches/lighters in the zones;
- Check in/check out at access control points;
- Use buddy system;
- Wear appropriate PPE;
- Avoid walking through puddles or stained soil; and

Table 9.1 Internal Emergency Communications Signals

Devices(a) and Signals	Example
Noisemakers, such as: Bell Compressed air horn Megaphone Siren Whistle	One long blast: Evacuate area by nearest emergency exit. Two short blasts: Localized problem (not dangerous to workers). Two long blasts: all clear.
Visual signal, including: Hand signals Whole body movements	Hand clutching throat: Out of air/can't breathe. Hands on top of head: need assistance. Thumbs up: OK/I'm alright/I understand. Thumbs down: No/negative. Grip partner's wrist or both hands around partners waist: Leave area immediately.

(a) All devices and equipment used in the exclusion and contamination reduction zones must be intrinsically safe and not capable of sparking.

- Discovery of unusual or unexpected conditions will result in immediate evacuation and reassessment of site conditions and health and safety practices.

The following guidelines will also be followed while working on site:

- Conduct safety briefings prior to beginning work;
- Conduct daily/weekly safety meetings as necessary; and
- Take precautions to reduce injuries from heavy equipment, utilities, and other tools.

9.5 ACCIDENT PREVENTION

All ES personnel and subcontractors will receive health and safety training prior to the initiation of any site activities. On a day-to-day basis, individual personnel should be constantly alert for indicators of potentially hazardous situations and for signs and symptoms in themselves and others that warn of hazardous conditions and exposures. Rapid recognition of dangerous situations can avert an emergency. Before beginning field work each day, a tailgate meeting will be held to discuss accident prevention. Health and safety briefings are described in Section 4.2.

SECTION 10

SITE-SPECIFIC DECONTAMINATION PROCEDURES

10.1 PERSONNEL DECONTAMINATION PROCEDURES

An EZ, CRZ, and SZ will be established whenever field personnel are using PPE. Defined boundaries (access and egress points) will be established whenever feasible, and personnel will enter and exit only through these points. In addition, all personnel who are involved in daily field investigations will be required to shower as soon as possible after leaving for the day. MSDS sheets for decontamination fluids are located in Appendix B of this document.

All equipment that requires decontamination will be decontaminated according to the procedures described in the field sampling plan (ES, 1994b).

Decontamination procedures will be monitored by the SHSO.

10.1.1 Decontamination - OSHA Level D (Modified)

Decontamination stations for personnel in OSHA Level D - Modified will include provisions for removing disposable clothing and for washing hands, face and other exposed body parts. These procedures may be modified at the discretion of the SHSO.

10.1.2 Decontamination Procedures - OSHA Level C

When personnel are in OSHA Level C protection, a decontamination station will be set up in the area actively under investigation. The decontamination station layout shown in Figure 10.1 will be established and followed. The SHSO may modify these procedures if necessary. Three zones are defined: the exclusion zone, the contamination reduction zone, and the support zone.

10.1.3 Decontamination Procedure - OSHA Level B

If personnel are in OSHA Level B protection, the decontamination station layout shown in Figure 10.1 will be established and followed. These procedures may be modified as necessary by the SHSO. Level B operations typically require a minimum of four employees to effectively perform the particular activity. Two people will be in the hot zone, one person will be a backup with SCBA donned to assist the workers in the event of an emergency, and the fourth person will be in Level C in the CRZ to assist the team in decontamination upon exiting the hot zone. Three zones are defined: the exclusion zone, the contamination reduction zone, and

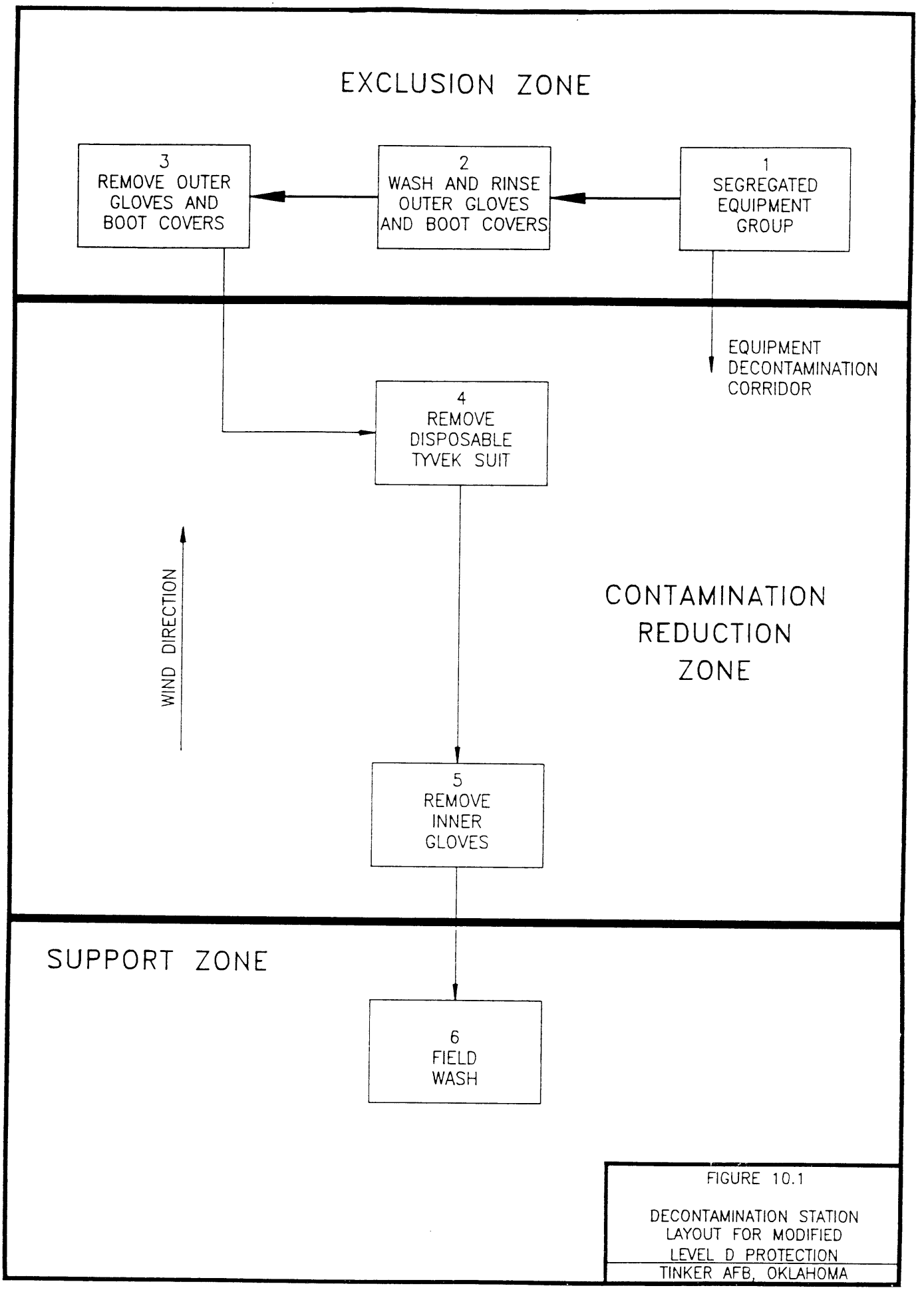

FIGURE 10.1

DECONTAMINATION STATION LAYOUT FOR MODIFIED LEVEL D PROTECTION

TINKER AFB, OKLAHOMA

the support zone. Each zone has a specified number of steps. (These steps do not necessarily indicate separate stations.)

10.2 DECONTAMINATION EQUIPMENT

Equipment decontamination during site operations may generate liquids from washing and rinsing procedures. All liquids produced will be collected and contained for appropriate disposal. Decontamination equipment will include:

- Plastic buckets and pails,
- Scrub brushes and long-handled brushes,
- Detergent (e.g., Alconox),
- ASTM type II water,
- Methanol,
- Hexane,
- Paper towels,
- Plastic garbage bags,
- Potable water,
- Disposal drums,
- Plastic liner material,
- Hand pump sprayers and benches, and
- An eye wash station.

Changes in the equipment used for decontamination may be made at the discretion of the SHSO.

REFERENCES

ES, 1994a. Work Plan for Remedial Investigation/Feasibility Study of the Soldier Creek/ITWP Groundwater Operable Unit at Tinker Air Force Base, Final. Prepared for Oklahoma City Air Logistics Center, Tinker Air Force Base, Oklahoma. Engineering-Science, Inc., May 1994.

ES, 1994b. Field Sampling Plan for Remedial Investigation/Feasibility Study of the Soldier Creek/ITWP Groundwater Operable Unit at Tinker Air Force Base, Final. Prepared for Oklahoma City Air Logistics Center, Tinker Air Force Base, Oklahoma. Engineering-Science, Inc., May 1994.

Hill, 1987. Emergency Medical Procedures for the Home, Auto, and Workplace, revision edition. The Deltakron Institute, New York: Prentice-Hall Press, 1987. Patricia B. Hill, Editor.

OSHA Title 29CFR 1910 and 1926.

USACE, 1991. Draft Off-Base Groundwater Investigation Report Northeast of Tinker Air Force Base, U.S. Army Corps of Engineers, Tulsa District, October 1991.

ES, 1991. Respiratory Protection Program for the Austin Engineering-Science office. Engineering-Science, Inc., March 1991.

Appendix A

Forms

JOB SAFETY & HEALTH PROTECTION

The Occupational Safety and Health Act of 1970 provides job safety and health protection for workers by promoting safe and healthful working conditions throughout the Nation. Provisions of the Act include

[illegible]

The OSHA citation must be prominently displayed at or near the place of alleged violation for three days, or until it is corrected, whichever is later, to warn employees of dangers that may exist there.

[illegible] *Part 1903.2(a)(1) employers must post this notice (or facsimile) in a conspicuous place where notices to employees are customarily posted.*

More Information

Additional information and copies of the Act, specific OSHA safety and health standards, and other applicable regulations may be obtained from your employer or from the nearest OSHA Regional Office in the following locations:

Atlanta, GA	(404) 347-3573
Boston, MA	(617) 565-7164
Chicago, IL	(312) 353-2220
Dallas, TX	(214) 767-4731
Denver, CO	(303) 844-3061
Kansas City, MO	(816) 426-5861
New York, NY	(212) 337-2378
Philadelphia, PA	(215) 596-1201
San Francisco, CA	(415) 744-6670
Seattle, WA	(206) 442-5930

Lynn Martin

Lynn Martin, Secretary of Labor

U.S. Department of Labor

Occupational Safety and Health Administration

Washington, DC
1991 (Reprinted)
OSHA 2203

To report suspected fire hazards, imminent danger safety and health hazards in the workplace, or other job safety and health emergencies, such as toxic waste in the workplace, call OSHA's 24-hour hotline: 1-800-321-OSHA.

ES ENGINEERING CORP. COMPANIES

ACCIDENT REPORT FORM

Project: _____

EMPLOYER

1. Name: _____

2. Mail Address: _____
(No. and Street) (City or Town) (State)

3. Location, if different from mail address: _____

_____

INJURED OR ILL EMPLOYEE

4. Name: _____ Social Security Number: _____
(First) (Middle) (Last)

5. Home Address: _____
(No. and Street) (City or Town) (State)

6. Age: _____ 7. Sex: Male ( ) Female ( )

8. Occupation: _____
(Specific job title, not the specific activity employee was performing at time of injury)

9. Department: _____
(Enter name of department in which injured persons is employed, even though they may have been temporarily working in another department at the time of injury)

THE ACCIDENT OR EXPOSURE TO OCCUPATIONAL ILLNESS

10. Place of accident of exposure: _____
(No. and Street) (City or Town) (State)

11. Was place of accident or exposure on employer's premises? Yes ( ) No ( )

12. What was the employee doing when injured? _____
(Be specific - Was employee

_____
using tools or equipment or handling material?)

_____

13. How did the accident occur? _____ (Describe fully the events that resulted in the injury or occupational illness. Tell what happened and how. Name objects and substances involved. Give details on all factors that led to accident. Use separate sheet for additional space.)

14. Time of accident: _____

15. ES WITNESS TO ACCIDENT _____ (Name) (Affiliation) (Phone No.)

_____ (Name) (Affiliation) (Phone No.)

_____ (Name) (Affiliation) (Phone No.)

OCCUPATIONAL INJURY OR OCCUPATIONAL ILLNESS

16. Describe injury or illness in detail; indicate part of body affected:

_____

_____

17. Name the object or substance that directly injured the employee. (For example, object that struck employee; the vapor or poison inhaled or swallowed; the chemical or radiation that irritated the skin; or in cases of strains, hernias, etc., the object the employee was lifting, pulling, etc.).

_____

_____

18. Date of injury or initial diagnosis of occupational illness _____ (Date)

19. Did the accident result in employee fatality? Yes ( ) No ( )

OTHER

20. Name and address of physician _____

_____

21. If hospitalized, name and address of hospital _____

_____

Date of report _____ Prepared by _____

Official position _____

Appendix B

Material Safety Data Sheets and Chemical Profiles

BNZ	BENZENE

Common Synonyms			
Benzol Benzole	Watery liquid	Colorless	Gasoline-like odor
	Floats on water. Flammable, irritating vapor is produced. Freezing point is 42° F.		

Avoid contact with liquid and vapor. Keep people away.
Wear goggles and self-contained breathing apparatus.
Shut off ignition sources and call fire department.
Stop discharge if possible.
Stay upwind and use water spray to "knock down" vapor.
Isolate and remove discharged material.
Notify local health and pollution control agencies.

Fire

FLAMMABLE.
Flashback along vapor trail may occur.
Vapor may explode if ignited in an enclosed area.
Wear goggles and self-contained breathing apparatus.
Extinguish with dry chemical, foam, or carbon dioxide.
Water may be ineffective on fire.
Cool exposed containers with water.

Exposure

CALL FOR MEDICAL AID.

VAPOR
Irritating to eyes, nose and throat.
If inhaled, will cause headache, difficult breathing, or loss of consciousness.
Move to fresh air.
If breathing has stopped, give artificial respiration.
If breathing is difficult, give oxygen.

LIQUID
Irritating to skin and eyes.
Harmful if swallowed.
Remove contaminated clothing and shoes.
Flush affected areas with plenty of water.
IF IN EYES, hold eyelids open and flush with plenty of water.
IF SWALLOWED and victim is CONSCIOUS, have victim drink water or milk.

Water Pollution

HARMFUL TO AQUATIC LIFE IN VERY LOW CONCENTRATIONS.
May be dangerous if it enters water intakes.
Notify local health and wildlife officials.
Notify operators of nearby water intakes.

1. RESPONSE TO DISCHARGE

(See Response Methods Handbook, CG 446-4)

Issue warning—high flammability
Restrict access

2. LABEL

Red

3. CHEMICAL DESIGNATIONS

3.1 **Synonyms:** Benzol
Benzole
3.2 **Coast Guard Compatibility Classification:** Aromatic hydrocarbon
3.3 **Chemical Formula:** C_6H_6
3.4 **IMCO/United Nations Numerical Designation:** 3.2/1114

4. OBSERVABLE CHARACTERISTICS

4.1 **Physical State (as shipped):** Liquid
4.2 **Color:** Colorless
4.3 **Odor:** Aromatic; rather pleasant aromatic odor; characteristic odor

5. HEALTH HAZARDS

5.1 **Personal Protective Equipment:** Hydrocarbon vapor canister, supplied air or a hose mask; hydrocarbon-insoluble rubber or plastic gloves; chemical goggles or face splash shield; hydrocarbon-insoluble apron such as neoprene.
5.2 **Symptoms Following Exposure:** Dizziness, excitation, pallor, followed by flushing, weakness, headache, breathlessness, chest constriction. Coma and possible death.
5.3 **Treatment for Exposure:** SKIN: flush with water followed by soap and water; remove contaminated clothing and wash skin. EYES: flush with plenty of water until irritation subsides. INHALATION: remove from exposure immediately. Call a physician. If breathing is irregular or stopped, start resuscitation, administer oxygen.
5.4 **Toxicity by Inhalation (Threshold Limit Value):** 25 ppm
5.5 **Short-Term Inhalation Limits:** 75 ppm for 30 min.
5.6 **Toxicity by Ingestion:** Grade 3; LD$_{50}$ 50 to 500 mg/kg
5.7 **Late Toxicity:** Leukemia
5.8 **Vapor (Gas) Irritant Characteristics:** If present in high concentrations, vapors may cause irritation of eyes or respiratory system. The effect is temporary.
5.9 **Liquid or Solid Irritant Characteristics:** Minimum hazard. If spilled on clothing and allowed to remain, may cause smarting and reddening of the skin.
5.10 **Odor Threshold:** 4.68 ppm

6. FIRE HAZARDS

6.1 **Flash Point:** 12°F C.C.
6.2 **Flammable Limits in Air:** 1.3%–7.9%
6.3 **Fire Extinguishing Agents:** Dry chemical, foam, or carbon dioxide
6.4 **Fire Extinguishing Agents Not to be Used:** Water may be ineffective
6.5 **Special Hazards of Combustion Products:** Not pertinent
6.6 **Behavior in Fire:** Vapor is heavier than air and may travel considerable distance to a source of ignition and flash back.
6.7 **Ignition Temperature:** 1097°F
6.8 **Electrical Hazard:** Class I, Group D
6.9 **Burning Rate:** 6.0 mm/min.

7. CHEMICAL REACTIVITY

7.1 **Reactivity with Water:** No reaction
7.2 **Reactivity with Common Materials:** No reaction
7.3 **Stability During Transport:** Stable
7.4 **Neutralizing Agents for Acids and Caustics:** Not pertinent
7.5 **Polymerization:** Not pertinent
7.6 **Inhibitor of Polymerization:** Not pertinent

8. WATER POLLUTION

8.1 **Aquatic Toxicity:**
5 ppm/6 hr/minnow/lethal/distilled water
20 ppm/24 hr/sunfish/TLm/tap water
8.2 **Waterfowl Toxicity:** Data not available
8.3 **Biological Oxygen Demand (BOD):** 1.2 lb/lb, 10 days
8.4 **Food Chain Concentration Potential:** None

9. SELECTED MANUFACTURERS

1. Commonwealth Oil Refining Co., Inc.
Commonwealth Petrochemicals Co.
Penuelas, Puerto Rico 00724
2. Phillips Petroleum Co.
Phillips Puerto Rico Core, Inc.
Banco Popular Center
Hato Rey, P.R. [illegible]
3. Shell Chemical Co.
Petrochemicals Div.
P.O. Box 2463
Houston, Texas 77001

10. SHIPPING INFORMATION

10.1 **Grades or Purity:**

Industrial pure	99+%
Thiophene free	99+%
Nitration	99+%
Industrial 90	85+%
Reagent	99+%

10.2 **Storage Temperature:** Ambient
10.3 **Inert Atmosphere:** No requirement
10.4 **Venting:** Pressure-vacuum

11. HAZARD ASSESSMENT CODE

(See Hazard Assessment Handbook, CG 446-3)

A-T-U-V-W

12. HAZARD CLASSIFICATIONS

12.1 **Code of Federal Regulations:** Flammable liquid
12.2 **NAS Hazard Rating for Bulk Water Transportation:**

Category	Rating
Fire	3
Health	
Vapor Irritant	1
Liquid or Solid Irritant	1
Poisons	3
Water Pollution	
Human Toxicity	1
Aquatic Toxicity	3
Aesthetic Effect	2
Reactivity	
Other Chemicals	1
Water	0
Self-Reaction	0

12.3 **NFPA Hazard Classifications:**

Category	Classification
Health Hazard (Blue)	2
Flammability (Red)	3
Reactivity (Yellow)	0

13. PHYSICAL AND CHEMICAL PROPERTIES

13.1 **Physical State at 15°C and 1 atm:** Liquid
13.2 **Molecular Weight:** 78.11
13.3 **Boiling Point at 1 atm:** 176°F = 80.1°C = 353.3°K
13.4 **Freezing Point:** 42.0°F = 5.5°C = 278.7°K
13.5 **Critical Temperature:** 552.0°F = 288.9°C = 562.1°K
13.6 **Critical Pressure:** 710 psia = 48.3 atm = 4.89 MN/m²
13.7 **Specific Gravity:** 0.879 at 20°C (liquid)
13.8 **Liquid Surface Tension:** 28.9 dynes/cm = 0.0289 N/m at 20°C
13.9 **Liquid-Water Interfacial Tension:** 35.0 dynes/cm = 0.035 N/m at 20°C
13.10 **Vapor (Gas) Specific Gravity:** 2.7
13.11 **Ratio of Specific Heats of Vapor (Gas):** 1.061
13.12 **Latent Heat of Vaporization:** 169 Btu/lb = 94.1 cal/g = 3.94×10^5 J/kg
13.13 **Heat of Combustion:** −17,460 Btu/lb = −9698 cal/g = -406.0×10^5 J/kg
13.14 **Heat of Decomposition:** Not pertinent
13.15 **Heat of Solution:** Not pertinent
13.16 **Heat of Polymerization:** Not pertinent

NOTES

REVISED 1978

CRB

CHLOROBENZENE

Common Synonyms
Monochlorobenzene
Phenyl chloride
Benzene chloride

Watery liquid. Colorless Sweet, almond odor

Sinks in water. Flammable vapor is produced.

Avoid contact with liquid and vapor. Keep people away.
Stop discharge if possible.
Call fire department.
Stay upwind and use water spray to "knock down" vapor.
Isolate and remove discharged material.
Notify local health and pollution control agencies.

Fire

FLAMMABLE
Flashback along vapor trail may occur.
Vapor may explode if ignited in an enclosed area.

Wear goggles and self-contained breathing apparatus.
Extinguish with dry chemical, foam, or carbon dioxide.

Exposure

CALL FOR MEDICAL AID.

VAPOR
If inhaled, will cause coughing or dizziness.
Not irritating to eyes, nose and throat.
Move to fresh air.
If breathing has stopped, give artificial respiration.
If breathing is difficult, give oxygen.

LIQUID
Irritating to skin and eyes.
Harmful if swallowed.
Remove contaminated clothing and shoes.
Flush affected areas with plenty of water.
IF IN EYES, hold eyelids open and flush with plenty of water.
IF SWALLOWED and victim is CONSCIOUS, have victim drink water or milk.

Water Pollution

HARMFUL TO AQUATIC LIFE IN VERY LOW CONCENTRATIONS.
May be dangerous if it enters water intakes.
Notify local health and wildlife officials.
Notify operators of nearby water intakes.

1. RESPONSE TO DISCHARGE

(See Response Methods Handbook, CG 446-4)

Should be removed.
Chemical and physical treatment.

2. LABEL

Red

3. CHEMICAL DESIGNATIONS

3.1 **Synonyms:**
Benzene chloride
MCB
Monochlorobenzene
Phenyl chloride

3.2 **Coast Guard Compatibility Classification:** Halogenated hydrocarbon

3.3 **Chemical Formula:** C_6H_5Cl

3.4 **IMCO/United Nations Numerical Designation:** 3.3/1134

4. OBSERVABLE CHARACTERISTICS

4.1 **Physical State (as shipped):** Liquid

4.2 **Color:** Colorless

4.3 **Odor:** Mild amine odor; sweet, almond-like, aromatic

5. HEALTH HAZARDS

5.1 **Personal Protective Equipment:** Organic vapor-acid gas respirator where appropriate; neoprene or vinyl gloves; chemical safety spectacles, plus face shield where appropriate; rubber footwear, apron or impervious clothing for splash protection; hard hat.

5.2 **Symptoms Following Exposure:** Irritating to skin, eyes and mucous membranes. Repeated exposure of skin may cause dermatitis due to defatting action. Chronic inhalation of vapors or mist may result in damage to lungs, liver, and kidneys. Acute vapor exposures can cause symptoms ranging from coughing to transient anesthesia and central nervous system depression.

5.3 **Treatment for Exposure:** Get medical attention for all eye exposures and any serious over-exposures. Treat the symptoms. INHALATION: remove to clean air; administer oxygen as needed. INGESTION: dilute by drinking water; if vomiting occurs, administer more water. Administer saline laxative. EYES: flush thoroughly with water. SKIN: remove contaminated clothing, wash exposed area with soap and water.

5.4 **Toxicity by Inhalation (Threshold Limit Value):** 75 ppm

5.5 **Short-Term Inhalation Limits:** Data not available

5.6 **Toxicity by Ingestion:** Grade 2; LD_{50} 0.5 to 5 g/kg (rat, rabbit)

5.7 **Late Toxicity:** Data not available

5.8 **Vapor (Gas) Irritant Characteristics:** Vapors are nonirritating to the eyes and throat.

5.9 **Liquid or Solid Irritant Characteristics:** Minimum hazard. If spilled on clothing and allowed to remain, may cause smarting and reddening of the skin.

5.10 **Odor Threshold:** 0.21 ppm

6. FIRE HAZARDS

6.1 **Flash Point:** 84°F C.C., 92°F O.C.

6.2 **Flammable Limits in Air:** 1.3% - 7.1%

6.3 **Fire Extinguishing Agents:** Carbon dioxide, dry chemical, foam or water spray.

6.4 **Fire Extinguishing Agents Not to be Used:** Not pertinent.

6.5 **Special Hazards of Combustion Products:** Burning in open flame can form toxic phosgene and hydrogen chloride gases.

6.6 **Behavior in Fire:** Heavy vapor can travel a considerable distance to a source of ignition and flash back.

6.7 **Ignition Temperature:** 1184°F

6.8 **Electrical Hazard:** Data not available.

6.9 **Burning Rate:** (est.) 4.6 mm/min.

7. CHEMICAL REACTIVITY

7.1 **Reactivity with Water:** No reaction.

7.2 **Reactivity with Common Materials:** No reaction.

7.3 **Stability During Transport:** Stable.

7.4 **Neutralizing Agents for Acids and Caustics:** Not pertinent.

7.5 **Polymerization:** Not pertinent.

7.6 **Inhibitor of Polymerization:** Not pertinent.

8. WATER POLLUTION

8.1 **Aquatic Toxicity:** 20 ppm/96 hr/bluegill/TL_m/fresh water

8.2 **Waterfowl Toxicity:** Data not available.

8.3 **Biological Oxygen Demand (BOD):** 0.31 lb/lb, 5 days.

8.4 **Food Chain Concentration Potential:** Data not available.

9. SELECTED MANUFACTURERS

1. Dow Chemical Co.
Midland, Mich. 48640
2. Monsanto Co.
Monsanto Industrial Chemicals Co.
800 North Lindbergh Blvd.
St. Louis, Mo. 63166
3. Montrose Chemical Corp.
500 South Virgil Ave.
Los Angeles, Calif. 90005

10. SHIPPING INFORMATION

10.1 **Grades or Purity:** 99.5%, technical

10.2 **Storage Temperature:** Ambient

10.3 **Inert Atmosphere:** No requirement

10.4 **Venting:** Pressure-vacuum

11. HAZARD ASSESSMENT CODE

(See Hazard Assessment Handbook, CG 446-3)

A-T-X

12. HAZARD CLASSIFICATIONS

12.1 **Code of Federal Regulations:** Flammable Liquid

12.2 **NAS Hazard Rating for Bulk Water Transportation:**

Category	Rating
Fire	3
Health	
Vapor Irritant	0
Liquid or Solid Irritant	1
Poisons	2
Water Pollution	
Human Toxicity	1
Aquatic Toxicity	3
Aesthetic Effect	2
Reactivity	
Other Chemicals	1
Water	0
Self-Reaction	0

12.3 **NFPA Hazard Classifications:**

Category	Classification
Health Hazard (Blue)	2
Flammability (Red)	3
Reactivity (Yellow)	0

13. PHYSICAL AND CHEMICAL PROPERTIES

13.1 **Physical State at 15°C and 1 atm:** Liquid

13.2 **Molecular Weight:** 112.56

13.3 **Boiling Point at 1 atm:** 270°F = 132°C = 405°K

13.4 **Freezing Point:** −50.1°F = −45.6°C = 227.6°K

13.5 **Critical Temperature:** 678°F = 359°C = 632°K

13.6 **Critical Pressure:** 656 psia = 44.6 atm = 4.52 MN/m²

13.7 **Specific Gravity:** 1.11 at 20°C (liquid)

13.8 **Liquid Surface Tension:** 33 dynes/cm = 0.033 N/m at 25°C

13.9 **Liquid-Water Interfacial Tension:** 37.41 dynes/cm = 0.03741 N/m at 20°C

13.10 **Vapor (Gas) Specific Gravity:** Not pertinent

13.11 **Ratio of Specific Heats of Vapor (Gas):** 1.094

13.12 **Latent Heat of Vaporization:** 135 Btu/lb = 75 cal/g = 3.140 × 10⁵ J/kg

13.13 **Heat of Combustion:** (est.) 12,000 Btu/lb = 6700 cal/g = 280 x 10⁵ J/kg

13.14 **Heat of Decomposition:** Not pertinent

13.15 **Heat of Solution:** Not pertinent

13.16 **Heat of Polymerization:** Not pertinent

NOTES

REVISED 1978

DBO

o-DICHLOROBENZENE

Common Synonyms
1,2-Dichlorobenzene
Orthodichlorobenzene

Liquid | Colorless | Pleasant odor

Sinks in water

Avoid contact with liquid.
Wear goggles and self-contained breathing apparatus.
Stop discharge if possible.
Call fire department.
Isolate and remove discharged material.
Notify local health and pollution control agencies.

Fire

Combustible
POISONOUS GASES ARE PRODUCED IN FIRE
Wear goggles and self-contained breathing apparatus.
Extinguish with water, dry chemical, foam, or carbon dioxide.
Cool exposed containers with water.

Exposure

CALL FOR MEDICAL AID

LIQUID
Irritating to skin and eyes.
Harmful if swallowed.
Remove contaminated clothing and shoes.
Flush affected areas with plenty of water.
IF IN EYES, hold eyelids open and flush with plenty of water.
IF SWALLOWED and victim is CONSCIOUS, have victim drink water or milk and have victim induce vomiting.
IF SWALLOWED and victim is UNCONSCIOUS OR HAVING CONVULSIONS, do nothing except keep victim warm.

Water Pollution

Effect of low concentrations on aquatic life is unknown.
May be dangerous if it enters water intakes.
Notify local health and pollution control officials.
Notify operators of nearby water intakes.

1. RESPONSE TO DISCHARGE

(See Response Methods Handbook, CG 446-4)

Issue warning – water contaminant
Should be removed
Chemical and physical treatment

2. LABELS

No hazard label required by Code of Federal Regulations

3. CHEMICAL DESIGNATIONS

3.1 **Synonyms:**
1,2-Dichlorobenzene
Dowtherm E
Orthodichlorobenzene

3.2 **Coast Guard Compatibility Classification:** Halogenated hydrocarbon

3.3 **Chemical Formula:** $o\text{-}C_6H_4Cl_2$

3.4 **IMCO/United Nations Numerical Designation:** 6.1/1591

4. OBSERVABLE CHARACTERISTICS

4.1 **Physical State (as shipped):** Liquid

4.2 **Color:** Colorless

4.3 **Odor:** Aromatic, characteristic aromatic

5. HEALTH HAZARDS

5.1 **Personal Protective Equipment:** Organic vapor-acid gas respirator, neoprene or vinyl gloves, chemical safety spectacles, face shield, rubber footwear, apron, protective clothing.

5.2 **Symptoms Following Exposure:** Chronic inhalation of mist or vapors may result in damage to lungs, liver, and kidneys. Acute vapor exposure can cause symptoms ranging from coughing to central nervous system depression and transient anesthesia. Irritating to skin, eyes, and mucous membranes. May cause dermatitis.

5.3 **Treatment for Exposure:** INHALATION: remove victim to fresh air, keep him quiet and warm, and call a physician promptly. INGESTION: no known antidote; treat symptomatically; induce vomiting and get medical attention promptly. EYES AND SKIN: flush with plenty of water; get medical attention for eyes; remove contaminated clothing and wash before reuse.

5.4 **Toxicity by Inhalation (Threshold Limit Value):** 50 ppm

5.5 **Short-Term Inhalation Limits:** 50 ppm for 15 min.

5.6 **Toxicity by Ingestion:** Grade 2; LD_{50} 0.5 to 5 g/kg

5.7 **Late Toxicity:** Causes kidney and liver damage in rats. Effects unknown in humans.

5.8 **Vapor (Gas) Irritant Characteristics:** Vapors cause moderate irritation such that personnel will find high concentrations unpleasant. The effect is temporary.

5.9 **Liquid or Solid Irritant Characteristics:** Minimum hazard. If spilled on clothing and allowed to remain, may cause smarting and reddening of the skin.

5.10 **Odor Threshold:** 4.0 ppm; 50 ppm

6. FIRE HAZARDS

6.1 **Flash Point:** 165°F O.C., 155°F C.C.

6.2 **Flammable Limits in Air:** 2.2% - 9.2%

6.3 **Fire Extinguishing Agents:** Water, foam, dry chemical, or carbon dioxide

6.4 **Fire Extinguishing Agents Not to be Used:** Not pertinent

6.5 **Special Hazards of Combustion Products:** Irritating vapors including hydrogen chloride gas, chlorocarbons, chlorine

6.6 **Behavior in Fire:** Not pertinent

6.7 **Ignition Temperature:** 1198°F

6.8 **Electrical Hazard:** Not pertinent

6.9 **Burning Rate:** 1.3 mm/min

7. CHEMICAL REACTIVITY

7.1 **Reactivity with Water:** No reaction

7.2 **Reactivity with Common Materials:** No reaction

7.3 **Stability During Transport:** Stable

7.4 **Neutralizing Agents for Acids and Caustics:** Not pertinent

7.5 **Polymerization:** Not pertinent

7.6 **Inhibitor of Polymerization:** Not pertinent

8. WATER POLLUTION

8.1 **Aquatic Toxicity:** 13 ppm/*/marine plankton/no growth/salt water

*Time period not specified

8.2 **Waterfowl Toxicity:** Data not available

8.3 **Biological Oxygen Demand (BOD):** <0.1% (theor.) 1/8 day

8.4 **Food Chain Concentration Potential:** Data not available

9. SELECTED MANUFACTURERS

1. Dow Chemical Co.
Midland, Mich. 48640

2. Monsanto Co.
Monsanto Industrial Chemicals Co.
800 North Lindbergh Blvd.
St. Louis, Mo. 63166

3. Standard Chlorine Chemical Co., Inc.
1015 25 Belleville Turnpike
Kearney, N. J. 07032

10. SHIPPING INFORMATION

10.1 **Grades or Purity:**
Technical 99.5% min. dichlorobenzene (ratio ortho + para/meta 80 min.)
Technical 85% orthodichlorobenzene, 14.0% paradichlorobenzene
Technical 80% ortho, 17% para, 2% meta
Pure: not less than 99.5% ortho, not more than 0.5% para

10.2 **Storage Temperature:** Data not available

(Continued on page 4)

11. HAZARD ASSESSMENT CODE

(See Hazard Assessment Handbook, CG 446-3)

A.X-Y

12. HAZARD CLASSIFICATIONS

12.1 **Code of Federal Regulations:** ORM-A

12.2 **NAS Hazard Rating for Bulk Water Transportation:**

Category	Rating
Fire	1
Health	
Vapor Irritant	2
Liquid or Solid Irritant	1
Poisons	1
Water Pollution	
Human Toxicity	1
Aquatic Toxicity	3
Aesthetic Effect	2
Reactivity	
Other Chemicals	1
Water	0
Self-Reaction	0

12.3 **NFPA Hazard Classifications:**

Category	Classification
Health Hazard (Blue)	2
Flammability (Red)	2
Reactivity (Yellow)	0

13. PHYSICAL AND CHEMICAL PROPERTIES

13.1 **Physical State at 15°C and 1 atm:** Liquid

13.2 **Molecular Weight:** 147.01

13.3 **Boiling Point at 1 atm:** 356.9°F = 180.5°C = 453.7°K

13.4 **Freezing Point:** 0.3°F = −17.6°C = 255.6°K

13.5 **Critical Temperature:** Not pertinent

13.6 **Critical Pressure:** Not pertinent

13.7 **Specific Gravity:** 1.306 at 20°C (liquid)

13.8 **Liquid Surface Tension:** 37 dynes/cm = 0.037 N/m at 20°C

13.9 **Liquid-Water Interfacial Tension:** (est.) 40 dynes/cm = 0.04 N/m at 20°C

13.10 **Vapor (Gas) Specific Gravity:** Not pertinent

13.11 **Ratio of Specific Heats of Vapor (Gas):** 1.080

13.12 **Latent Heat of Vaporization:** 115 Btu/lb = 63.9 cal/g = 2.68×10^5 J/kg

13.13 **Heat of Combustion:** −7969 Btu/lb = −4427 cal/g = -185.4×10^5 J/kg

13.14 **Heat of Decomposition:** Not pertinent

13.15 **Heat of Solution:** Not pertinent

13.16 **Heat of Polymerization:** Not pertinent

10. SHIPPING INFORMATION (Cont'd.)

10.3 **Inert Atmosphere:** Data not available

10.4 **Venting:** Data not available

REVISED 1978

DEL

1,2-DICHLOROETHYLENE

Common Synonyms

Acetylene dichloride
sym-dichloroethylene
Dioform
cis-1,2-dichloroethylene
trans-1,2-dichloroethylene

Liquid | Colorless | Sweet pleasant odor

Sinks in water. Flammable, irritating vapor is produced.

Wear goggles and self-contained breathing apparatus.
Shut off ignition sources. Call fire department.
Stop discharge if possible. Keep people away.
Isolate and remove discharged material.
Notify local health and pollution control agencies.

Fire

FLAMMABLE.
POISONOUS GASES MAY BE PRODUCED IN FIRE.
Containers may explode in fire.
Flashback along vapor trail may occur.
Vapor may explode if ignited in an enclosed area.
Extinguish with dry chemicals, foam or carbon dioxide.
Water may be ineffective on fire.
Cool exposed containers with water.

Exposure

Call for medical aid.

VAPOR

If inhaled will cause dizziness, nausea, vomiting, or difficult breathing.
Move victim to fresh air.
If breathing has stopped, give artificial respiration.
If breathing is difficult, give oxygen.

LIQUID

Harmful if swallowed.
IF SWALLOWED and victim is CONSCIOUS, have victim drink water or milk.

Water Pollution

Effect of low concentrations on aquatic life is unknown.
May be dangerous if it enters water intakes.
Notify local health and wildlife officials.
Notify operators of nearby water intakes.

1. RESPONSE TO DISCHARGE

(See Response Methods Handbook CG 446-4)

Issue warning—high flammability.
Restrict access.
Evacuate area.
Should be removed.
Chemical and physical treatment.

2. LABEL

Red

3. CHEMICAL DESIGNATIONS

3.1 **Synonyms:** Acetylene dichloride; sym-Dichloroethylene; Dioform; cis- or trans-1,2-Dichloroethylene

3.2 **Coast Guard Compatibility Classification:** Not applicable

3.3 **Chemical Formula:** ClCH=CHCl

3.4 **IMCO/United Nations Numerical Designation:** 3.2/1150

4. OBSERVABLE CHARACTERISTICS

4.1 **Physical State (as shipped):** Liquid

4.2 **Color:** Colorless

4.3 **Odor:** Ethereal, slightly acrid, pleasant; chloroform-like

5. HEALTH HAZARDS

5.1 **Personal Protective Equipment:** Rubber gloves; safety goggles; air supply mask or self-contained breathing apparatus

5.2 **Symptoms Following Exposure:** Inhalation causes nausea, vomiting, weakness, tremor, epigastric cramps, central nervous depression. Contact with liquid causes irritation of eyes and (on prolonged contact) skin. Ingestion causes slight depression to deep narcosis.

5.3 **Treatment for Exposure:** INHALATION: remove from further exposure, if breathing is difficult, give oxygen, if victim is not breathing, give artificial respiration, preferably mouth-to-mouth; give oxygen when breathing is resumed; call a physician. EYES: flush with water for at least 15 min. SKIN: wash well with soap and water. INGESTION: give gastric lavage and cathartics.

5.4 **Toxicity by Inhalation (Threshold Limit Value):** 200 ppm

5.5 **Short-Term Inhalation Limits:** Data not available

5.6 **Toxicity by Ingestion:** Grade 2, oral LD_{50} = 770 mg/kg (rat)

5.7 **Late Toxicity:** Produces liver and kidney injury in experimental animals

5.8 **Vapor (Gas) Irritant Characteristics:** Data not available

5.9 **Liquid or Solid Irritant Characteristics:** Data not available

5.10 **Odor Threshold:** Data not available

6. FIRE HAZARDS

6.1 **Flash Point:** 37°F C.C.

6.2 **Flammable Limits in Air:** 9.7% - 12.8%

6.3 **Fire Extinguishing Agents:** Dry chemical, foam, carbon dioxide

6.4 **Fire Extinguishing Agents Not to be Used:** Water may be ineffective

6.5 **Special Hazards of Combustion Products:** Phosgene and hydrogen chloride fumes may form in fires.

6.6 **Behavior in Fire:** Vapor is heavier than air and may travel a considerable distance to a source of ignition and flash back.

6.7 **Ignition Temperature:** Data not available

6.8 **Electrical Hazard:** Data not available

6.9 **Burning Rate:** 2.6 mm/min

7. CHEMICAL REACTIVITY

Reactivity with Water: No reaction

Reactivity with Common Materials: No reaction

7.3 **Stability During Transport:** Stable

7.4 **Neutralizing Agents for Acids and Caustics:** Not pertinent

7.5 **Polymerization:** Will not occur under ordinary conditions of shipment. The reaction is not vigorous.

7.6 **Inhibitor of Polymerization:** None used

8. WATER POLLUTION

8.1 **Aquatic Toxicity:** Data not available

8.2 **Waterfowl Toxicity:** Data not available

8.3 **Biological Oxygen Demand (BOD):** Data not available

8.4 **Food Chain Concentration Potential:** None

9. SELECTED MANUFACTURERS

1. Eastman Kodak Co.
Eastman Organic Chemicals
Rochester, N.Y. 14650

2. Dynamit Nobel A.G.
105 Stonehurst Court
Northvale, N.J. 07647

3. Pfaltz and Bauer, Inc.
126-04 Northern Boulevard
Flushing, N.Y. 11368

10. SHIPPING INFORMATION

10.1 **Grades or Purity:** Commercial

10.2 **Storage Temperature:** Ambient

10.3 **Inert Atmosphere:** No requirement

10.4 **Venting:** Pressure-vacuum

11. HAZARD ASSESSMENT CODE

(See Hazard Assessment Handbook CG 446-3)

A-X-Y

12. HAZARD CLASSIFICATIONS

12.1 **Code of Federal Regulations:** Flammable liquid

12.2 **NAS Hazard Rating for Bulk Water Transportation:** Not listed

12.3 **NFPA Hazard Classifications:**

Category	Classification
Health Hazard (Blue)	2
Flammability (Red)	3
Reactivity (Yellow)	2

13. PHYSICAL AND CHEMICAL PROPERTIES

13.1 **Physical State at 15°C and 1 atm:** Liquid

13.2 **Molecular Weight:** 97.0

13.3 **Boiling Point at 1 atm:**
cis: 140°F = 60°C = 333°K
trans: 118°F = 48°C = 321°K

13.4 **Freezing Point:**
cis: −114°F = −81°C = 192°K
trans: −58°F = −50°C = 223°K

13.5 **Critical Temperature:** Not pertinent

13.6 **Critical Pressure:** Not pertinent

13.7 **Specific Gravity:** 1.27 at 25°C (liquid)

13.8 **Liquid Surface Tension:**
24 dynes/cm = 0.024 N/m at 20°C

13.9 **Liquid-Water Interfacial Tension:** (est.)
30 dynes/cm = 0.030 N/m at 20°C

13.10 **Vapor (Gas) Specific Gravity:** 3.34

13.11 **Ratio of Specific Heats of Vapor (Gas):**
1.1468

13.12 **Latent Heat of Vaporization:** 130 Btu/lb
= 72 cal/g = 3.0×10^5 J/kg

13.13 **Heat of Combustion:** −4,847.2 Btu/lb
= −2,692.9 cal/g = -112.67×10^5 J/kg

13.14 **Heat of Decomposition:** Not pertinent

13.15 **Heat of Solution:** Not pertinent

13.16 **Heat of Polymerization:** Not pertinent

NOTES

ETB — ETHYLBENZENE

Common Synonyms
Phenylethane
EB

Liquid Colorless Sweet, gasoline-like odor

Floats on water. Flammable, irritating vapor is produced.

Avoid contact with liquid and vapor. Keep people away.
Wear goggles, self-contained breathing apparatus, and rubber overclothing (including gloves).
Shut off ignition sources and call fire department.
Stop discharge if possible.
Stay upwind and use water spray to "knock down" vapor.
Isolate and remove discharged material.
Notify local health and pollution control agencies.

Fire

FLAMMABLE.
Flashback along vapor trail may occur.
Vapor may explode if ignited in an enclosed area.
Wear goggles, self-contained breathing apparatus, and rubber overclothing (including gloves).
Extinguish with dry chemical, foam, or carbon dioxide.
Water may be ineffective on fire.
Cool exposed containers with water.

Exposure

CALL FOR MEDICAL AID.

VAPOR
Irritating to eyes, nose and throat.
If inhaled, will cause dizziness or difficult breathing.
Move to fresh air.
If breathing has stopped, give artificial respiration.
If breathing is difficult, give oxygen.

LIQUID
Will burn skin and eyes.
Harmful if swallowed.
Remove contaminated clothing and shoes.
Flush affected areas with plenty of water.
IF IN EYES, hold eyelids open and flush with plenty of water.
IF SWALLOWED and victim is CONSCIOUS, have victim drink water or milk.
DO NOT INDUCE VOMITING.

Water Pollution

HARMFUL TO AQUATIC LIFE IN VERY LOW CONCENTRATIONS.
Fouling to shoreline.
May be dangerous if it enters water intakes.
Notify local health and wildlife officials.
Notify operators of nearby water intakes.

1. RESPONSE TO DISCHARGE

(See Response Methods Handbook, CG 446-4)

Mechanical containment
Should be removed
Chemical and physical treatment

2. LABEL

Red

3. CHEMICAL DESIGNATIONS

3.1 **Synonyms:** EB
Phenylethane

3.2 **Coast Guard Compatibility Classification:**
Aromatic hydrocarbon

3.3 **Chemical Formula:** $C_6H_5CH_2CH_3$

3.4 **IMCO/United Nations Numerical Designation:** 3.3/1175

4. OBSERVABLE CHARACTERISTICS

4.1 **Physical State (as shipped):** Liquid

4.2 **Color:** Colorless

4.3 **Odor:** Aromatic

5. HEALTH HAZARDS

5.1 **Personal Protective Equipment:** Self-contained breathing apparatus; safety goggles.

5.2 **Symptoms Following Exposure:** Inhalation may cause irritation of nose; dizziness, depression. Moderate irritation of eye with corneal injury possible. Irritates skin and may cause blisters.

5.3 **Treatment for Exposure:** INHALATION: if ill effects occur, remove victim to fresh air, keep him warm and quiet, and get medical help promptly; if breathing stops, give artificial respiration. INGESTION: induce vomiting only upon physician's approval; material in lung may cause chemical pneumonitis. SKIN AND EYES: promptly flush with plenty of water (15 min. for eyes) and get medical attention; remove and wash contaminated clothing before reuse.

5.4 **Toxicity by Inhalation (Threshold Limit Value):** 100 ppm

5.5 **Short-Term Inhalation Limits:** 200 ppm for 30 min

5.6 **Toxicity by Ingestion:** Grade 2; LD_{50} 0.5 to 5 g/kg (rat)

5.7 **Late Toxicity:** Data not available

5.8 **Vapor (Gas) Irritant Characteristics:** Vapors cause moderate irritation such that personnel will find high concentrations unpleasant. The effect is temporary.

5.9 **Liquid or Solid Irritant Characteristics:** Causes smarting of the skin and first-degree burns on short exposure; may cause secondary burns on long exposure.

5.10 **Odor Threshold:** 140 ppm

6. FIRE HAZARDS

6.1 **Flash Point:** 80°F C.C. = 59°F C.C.

6.2 **Flammable Limits in Air:**
1.0% - 6.7%

6.3 **Fire Extinguishing Agents:** Foam (most effective), water fog, carbon dioxide or dry chemical.

6.4 **Fire Extinguishing Agents Not to be Used:** Not pertinent.

6.5 **Special Hazards of Combustion Products:** Irritating vapors are generated when heated.

6.6 **Behavior in Fire:** Vapor is heavier than air and may travel considerable distance to the source of ignition and flash back.

6.7 **Ignition Temperature:** 860°F

6.8 **Electrical Hazard:** Not pertinent.

6.9 **Burning Rate:** 3.8 mm/min.

7. CHEMICAL REACTIVITY

7.1 **Reactivity with Water:** No reaction.

7.2 **Reactivity with Common Materials:** No reaction.

7.3 **Stability During Transport:** Stable.

7.4 **Neutralizing Agents for Acids and Caustics:** Not pertinent.

7.5 **Polymerization:** Not pertinent.

7.6 **Inhibitor of Polymerization:** Not pertinent.

8. WATER POLLUTION

8.1 **Aquatic Toxicity:** 29 ppm/96 hr/bluegill/TL_m/fresh water

8.2 **Waterfowl Toxicity:** Data not available.

8.3 **Biological Oxygen Demand (BOD):** 2.8% (theor.), 5 days

8.4 **Food Chain Concentration Potential:** None.

9. SELECTED MANUFACTURERS

1. Amoco Chemicals Corp.
130 East Randolph Drive
Chicago, Ill. 60601
2. Dow Chemical Co.
Midland, Mich. 48640
3. Monsanto Co.
800 North Lindbergh Blvd.
St. Louis, Mo. 63166

10. SHIPPING INFORMATION

10.1 **Grades of Purity:** Research grade 99.98% pure grade 99.5% technical grade 99.0%

10.2 **Storage Temperature:** Ambient

10.3 **Inert Atmosphere:** No requirement.

10.4 **Venting:** Open (flame arrester) or pressure-vacuum.

11. HAZARD ASSESSMENT CODE

(See Hazard Assessment Handbook, CG 446-3)

A-T-U

12. HAZARD CLASSIFICATIONS

12.1 **Code of Federal Regulations:**
Flammable Liquid

12.2 **NAS Hazard Rating for Bulk Water Transportation:**

Category	Rating
Fire	3
Health	
Vapor Irritant	2
Liquid or Solid Irritant	2
Poisons	2
Water Pollution	
Human Toxicity	1
Aquatic Toxicity	3
Aesthetic Effect	2
Reactivity	
Other Chemicals	1
Water	0
Self-Reaction	0

12.3 **NFPA Hazard Classifications:**

Category	Classification
Health Hazard (Blue)	2
Flammability (Red)	3
Reactivity (Yellow)	0

13. PHYSICAL AND CHEMICAL PROPERTIES

13.1 **Physical State at 15°C and 1 atm:** Liquid

13.2 **Molecular Weight:** 106.17

13.3 **Boiling Point at 1 atm:**
277.2°F = 136.2°C = 409.4°K

13.4 **Freezing Point:**
−139°F = −95°C = 178°K

13.5 **Critical Temperature:**
651.0°F = 343.9°C = 617.1°K

13.6 **Critical Pressure:**
523 psia = 35.6 atm = 3.61 MN/m²

13.7 **Specific Gravity:** 0.867 at 20°C (liquid)

13.8 **Liquid Surface Tension:**
29.2 dynes/cm = 0.0292 N/m at 20°C

13.9 **Liquid-Water Interfacial Tension:**
35.48 dynes/cm = 0.03548 N/m at 20°C

13.10 **Vapor (Gas) Specific Gravity:**
Not pertinent

13.11 **Ratio of Specific Heats of Vapor (Gas):**
1.071

13.12 **Latent Heat of Vaporization:**
144 Btu/lb = 80.1 cal/g = 3.35 × 10⁵ J/kg

13.13 **Heat of Combustion:** −17,780 Btu/lb
= −9877 cal/g = −413.5 × 10⁵ J/kg

13.14 **Heat of Decomposition:** Not pertinent

13.15 **Heat of Solution:** Not pertinent

13.16 **Heat of Polymerization:** Not pertinent

NOTES

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HXA HEXANE

Common Synonyms
n-Hexane

Watery liquid | Colorless | Gasoline-like odor

Floats on water. Flammable, irritating vapor is produced.

Stop discharge if possible. Keep people away.
Shut off ignition sources and call fire department.
Stay upwind and use water spray to "knock down" vapor.
Isolate and remove discharged material.
Notify local health and pollution control agencies.

Fire

FLAMMABLE.
Flashback along vapor trail may occur.
Vapor may explode if ignited in an enclosed area.
Extinguish with dry chemical, foam, or carbon dioxide.
Water may be ineffective on fire.
Cool exposed containers with water.

Exposure

CALL FOR MEDICAL AID.

VAPOR
Irritating to nose and throat.
If inhaled, will cause coughing or dizziness.
Move to fresh air.
If breathing has stopped, give artificial respiration.
If breathing is difficult, give oxygen.

LIQUID
Irritating to skin and eyes.
If swallowed, will cause nausea or vomiting.
Remove contaminated clothing and shoes.
Flush affected areas with plenty of water.
IF IN EYES, hold eyelids open and flush with plenty of water.
IF SWALLOWED and victim is CONSCIOUS, have victim drink water or milk.
DO NOT INDUCE VOMITING.

Water Pollution

Effect of low concentrations on aquatic life is unknown.
Fouling to shoreline.
May be dangerous if it enters water intakes.
Notify local health and wildlife officials.
Notify operators of nearby water intakes.

1. RESPONSE TO DISCHARGE

(See Response Methods Handbook, CG 446-4)

Issue warning: high flammability
Evacuate area
Disperse and flush

2. LABEL

Red

3. CHEMICAL DESIGNATIONS

3.1 **Synonyms:** No common synonyms
3.2 **Coast Guard Compatibility Classification:** Paraffin
3.3 **Chemical Formula:** $CH_3(CH_2)_4CH_3$
3.4 **IMCO/United Nations Numerical Designation:** 3.1/1208

4. OBSERVABLE CHARACTERISTICS

4.1 **Physical State (as shipped):** Liquid
4.2 **Color:** Colorless
4.3 **Odor:** Like gasoline

5. HEALTH HAZARDS

5.1 **Personal Protective Equipment:** Eye protection (like gasoline)
5.2 **Symptoms Following Exposure:** INHALATION causes irritation of respiratory tract, cough, mild depression, cardiac arrhythmias. ASPIRATION causes severe lung irritation, coughing, pulmonary edema, excitement followed by depression. INGESTION causes nausea, vomiting, swelling of abdomen, headache, depression.
5.3 **Treatment for Exposure:** Call a doctor. INHALATION, maintain respiration, give oxygen if needed. ASPIRATION, enforce bed rest, give oxygen if needed. INGESTION, do NOT induce vomiting. SKIN OR EYES, wipe off, wash skin with soap and water, wash eyes with copious amounts of water.
5.4 **Toxicity by Inhalation (Threshold Limit Value):** 500 ppm
5.5 **Short-Term Inhalation Limits:** 800 ppm for 30 min
5.6 **Toxicity by Ingestion:** Very slight
5.7 **Late Toxicity:** None
5.8 **Vapor (Gas) Irritant Characteristics:** Vapors are nonirritating to the eyes and throat.
5.9 **Liquid or Solid Irritant Characteristics:** No appreciable hazard. Practically harmless to the skin.
5.10 **Odor Threshold:** Data not available.

6. FIRE HAZARDS

6.1 **Flash Point:** −7°F C.C.
6.2 **Flammable Limits in Air:** 1.2% - 7.5% v
6.3 **Fire Extinguishing Agents:** Foam, dry chemical, carbon dioxide
6.4 **Fire Extinguishing Agents Not to be Used:** Not pertinent
6.5 **Special Hazards of Combustion Products:** Not pertinent
6.6 **Behavior in Fire:** Vapors may explode
6.7 **Ignition Temperature:** 437°F
6.8 **Electrical Hazard:** Class I, group D
6.9 **Burning Rate:** 2.3 mm/min

7. CHEMICAL REACTIVITY

7.1 **Reactivity with Water:** No reaction
7.2 **Reactivity with Common Materials:** No reaction
7.3 **Stability During Transport:** Stable
7.4 **Neutralizing Agents for Acids and Caustics:** Not pertinent
7.5 **Polymerization:** Not pertinent
7.6 **Inhibitor of Polymerization:** Not pertinent

8. WATER POLLUTION

8.1 **Aquatic Toxicity:** Data not available
8.2 **Waterfowl Toxicity:** Data not available
8.3 **Biological Oxygen Demand (BOD):** 0% (theor.) 7 days
8.4 **Food Chain Concentration Potential:** None

9. SELECTED MANUFACTURERS

1. Humphrey Chemical Co.
Devine St.
North Haven, Conn. 06473
2. Phillips Petroleum Co.
Bartlesville, Okla. 74003
3. Skelly Oil Co.
Kansas City, Mo. 64141

10. SHIPPING INFORMATION

10.1 **Grades of Purity:** Research grade, technical grade
10.2 **Storage Temperature:** Ambient
10.3 **Inert Atmosphere:** No requirement
10.4 **Venting:** Open (flame arrester) or pressure vacuum

11. HAZARD ASSESSMENT CODE

(See Hazard Assessment Handbook, CG 446-3)

A.T.C.V.W.

12. HAZARD CLASSIFICATIONS

12.1 **Code of Federal Regulations:** Flammable liquid
12.2 **NAS Hazard Rating for Bulk Water Transportation:**

Category	Rating
Fire	3
Health	
Vapor Irritant	0
Liquid or Solid Irritant	0
Poisons	1
Water Pollution	
Human Toxicity	1
Aquatic Toxicity	1
Aesthetic Effect	1
Reactivity	
Other Chemicals	0
Water	0
Self-Reaction	0

12.3 **NFPA Hazard Classifications:**

Category	Classification
Health Hazard (Blue)	1
Flammability (Red)	3
Reactivity (Yellow)	0

13. PHYSICAL AND CHEMICAL PROPERTIES

13.1 **Physical State at 15°C and 1 atm:** Liquid
13.2 **Molecular Weight:** 86.17
13.3 **Boiling Point at 1 atm:** 155.7°F = 68.7°C = 341.9°K
13.4 **Freezing Point:** −219.3°F = −139.6°C = 133.6°K
13.5 **Critical Temperature:** 453.6°F = 234.2°C = 507.4°K
13.6 **Critical Pressure:** 436.6 psia = 29.7 atm = 3.01 MN/m²
13.7 **Specific Gravity:** 0.659 at 20°C (liquid)
13.8 **Liquid Surface Tension:** 18.4 dynes/cm = 0.0184 N/m at 20°C
13.9 **Liquid-Water Interfacial Tension:** 51.1 dynes/cm = 0.0511 N/m at 20°C
13.10 **Vapor (Gas) Specific Gravity:** 3.0
13.11 **Ratio of Specific Heats of Vapor (Gas):** 1.063
13.12 **Latent Heat of Vaporization:** 144 Btu/lb = 80.0 cal/g = 3.35 × 10⁵ J/kg
13.13 **Heat of Combustion:** −19,246 Btu/lb = −10,692 cal/g = −447.65 × 10³ J/kg
13.14 **Heat of Decomposition:** Not pertinent
13.15 **Heat of Solution:** Not pertinent
13.16 **Heat of Polymerization:** Not pertinent

NOTES

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IBL

ISOBUTYLENE

Common Synonyms
Isobutene
2-Methylpropene

Liquefied compressed gas Colorless Sweet gasoline-like odor

Floats and boils on water. Flammable visible vapor cloud is produced.

Stop discharge if possible. Keep people away.
Shut off ignition sources and call fire department.
Stay upwind and use water spray to "knock down" vapor.
Avoid contact with liquid.
Isolate and remove discharged material.
Notify local health and pollution control agencies.

Fire

FLAMMABLE.
Flashback along vapor trail may occur.
Vapor may explode if ignited in an enclosed area.
Stop flow of gas if possible.
Cool exposed containers and protect men effecting shutoff with water.
Let fire burn.
Extinguish small fires with water, dry chemical, or carbon dioxide.

Exposure

CALL FOR MEDICAL AID.

VAPOR
Irritating to eyes, nose, and throat.
If inhaled, will cause dizziness or loss of consciousness.
Move to fresh air.
If breathing has stopped, give artificial respiration.
If breathing is difficult, give oxygen.

LIQUID
Will cause frostbite.
Flush affected areas with plenty of water.
DO NOT RUB AFFECTED AREAS.

Water Pollution

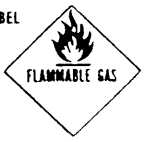
Not harmful to aquatic life.

1. RESPONSE TO DISCHARGE

(See Response Methods Handbook, CG 446-4)

Issue warning: high flammability
Restrict access
Evacuate area

2. LABEL



Red

3. CHEMICAL DESIGNATIONS

3.1 **Synonyms:** Isobutene
2-Methylpropene

3.2 **Coast Guard Compatibility Classification:** Olefin

3.3 **Chemical Formula:** $(CH_3)_2C=CH_2$

3.4 **IMCO/United Nations Numerical Designation:** 2/1055

4. OBSERVABLE CHARACTERISTICS

4.1 **Physical State (as shipped):** Liquid under pressure

4.2 **Color:** Colorless

4.3 **Odor:** Mild sweetish

5. HEALTH HAZARDS

5.1 **Personal Protective Equipment:** Chemical gloves and eye protection; organic vapor canister or self-contained breathing apparatus.

5.2 **Symptoms Following Exposure:** Inhalation of moderate concentrations causes dizziness, drowsiness and unconsciousness. Contact with eyes or skin may cause irritation; the liquid may cause frostbite.

5.3 **Treatment for Exposure:** INHALATION: remove victim to fresh air and apply resuscitation; call a physician promptly if victim is unconscious. EYES: if irritated, wash with water. SKIN: if irritated, wash with soap and water.

5.4 **Toxicity by Inhalation (Threshold Limit Value):** 1000 ppm (8 hr)

5.5 **Short-Term Inhalation Limits:** Data not available

5.6 **Toxicity by Ingestion:** Not pertinent

5.7 **Late Toxicity:** None

5.8 **Vapor (Gas) Irritant Characteristics:** Vapors are non-irritating to eyes and throat.

5.9 **Liquid or Solid Irritant Characteristics:** No appreciable hazard. Practically harmless to skin because it is very volatile and evaporates quickly. May cause frostbite.

5.10 **Odor Threshold:** Data not available

6. FIRE HAZARDS

6.1 **Flash Point:** −105°F C.C.

6.2 **Flammable Limits in Air:** 1.8% - 9.6%

6.3 **Fire Extinguishing Agents:** Let fire burn; stop flow of gas. Water fog, dry chemical, or carbon dioxide may be used for small fires.

6.4 **Fire Extinguishing Agents Not to be Used:** Not pertinent

6.5 **Special Hazards of Combustion Products:** Not pertinent

6.6 **Behavior in Fire:** Containers may explode in fire. Vapor is heavier than air and may travel a long distance to a source of ignition and flash back.

6.7 **Ignition Temperature:** 869°F

6.8 **Electrical Hazard:** Not pertinent

6.9 **Burning Rate:** Data not available

7. CHEMICAL REACTIVITY

7.1 **Reactivity with Water:** No reaction

7.2 **Reactivity with Common Materials:** No reaction

7.3 **Stability During Transport:** Stable

7.4 **Neutralizing Agents for Acids and Caustics:** Not pertinent

7.5 **Polymerization:** Not pertinent

7.6 **Inhibitor of Polymerization:** Not pertinent

8. WATER POLLUTION

8.1 **Aquatic Toxicity:** None

8.2 **Waterfowl Toxicity:** None

8.3 **Biological Oxygen Demand (BOD):** None

8.4 **Food Chain Concentration Potential:** None

9. SELECTED MANUFACTURERS

1. Petro-Tex Chemical Corp.
8600 Park Place
Houston, Texas 77017

2. Exxon Chemical Co.
Houston, Texas 77001

10. SHIPPING INFORMATION

10.1 **Grades or Purity:** Commercial, polymerization

10.2 **Storage Temperature:** Ambient

10.3 **Inert Atmosphere:** No requirement

10.4 **Venting:** Safety relief

11. HAZARD ASSESSMENT CODE

(See Hazard Assessment Handbook, CG 446-3)

A-B-C-D-E-F-G

12. HAZARD CLASSIFICATIONS

12.1 **Code of Federal Regulations:** Flammable compressed gas

12.2 **NAS Hazard Rating for Bulk Water Transportation:** Not listed

12.3 **NFPA Hazard Classifications:**

Category	Classification
Health Hazard (Blue)	1
Flammability (Red)	4
Reactivity (Yellow)	0

13. PHYSICAL AND CHEMICAL PROPERTIES

13.1 **Physical State at 15°C and 1 atm:** Gas

13.2 **Molecular Weight:** 56.10

13.3 **Boiling Point at 1 atm:** 19.6°F = −6.9°C = 266.3°K

13.4 **Freezing Point:** −220°F = −140.3°C = 132.9°K

13.5 **Critical Temperature:** 292.5°F = −144.7°C = 417.9°K

13.6 **Critical Pressure:** 580 psia = 39.48 atm = 3.99 MN/m²

13.7 **Specific Gravity:** 0.59 at 20°C (liquid)

13.8 **Liquid Surface Tension:** 15.8 dynes/cm = 0.0158 N/m at 20°C

13.9 **Liquid-Water Interfacial Tension:** (est.) 40 dynes/cm = 0.04 N/m at −40°C

13.10 **Vapor (Gas) Specific Gravity:** 1.9

13.11 **Ratio of Specific Heats of Vapor (Gas):** 1.061

13.12 **Latent Heat of Vaporization:** 170 Btu/lb = 94.3 cal/g = 3.95 × 10⁵ J/kg

13.13 **Heat of Combustion:** −19,359 Btu/lb = −10,755 cal/g = −450.29 × 10⁵ J/kg

13.14 **Heat of Decomposition:** Not pertinent

13.15 **Heat of Solution:** Not pertinent

13.16 **Heat of Polymerization:** Not pertinent

NOTES

REVISED 1978

MAL

METHYL ALCOHOL

Common Synonyms
Methanol
Wood alcohol
Wood naphtha
Wood spirit
Pyroxylic spirit

Watery liquid | Colorless | Alcohol odor

Floats and mixes with water. Flammable, irritating vapor is produced.

Stop discharge if possible. Keep people away.
Shut off ignition sources and call fire department.
Stay upwind and use water spray to "knock down" vapor.
Avoid contact with liquid and vapor.
Isolate and remove discharged material.
Notify local health and pollution control agencies.

Fire

FLAMMABLE.
Vapor may explode if ignited in an enclosed area.
Flashback along vapor trail may occur.
Extinguish with dry chemical, alcohol foam, or carbon dioxide.
Water may be ineffective on fire.
Cool exposed containers with water.

Exposure

CALL FOR MEDICAL AID.

VAPOR
Irritating to eyes, nose and throat.
If inhaled, will cause dizziness, headache, difficult breathing, or loss of consciousness.
Move to fresh air.
If breathing has stopped, give artificial respiration.
If breathing is difficult, give oxygen.

LIQUID
POISONOUS IF SWALLOWED.
Irritating to skin and eyes.
Remove contaminated clothing and shoes.
Flush affected areas with plenty of water.
IF IN EYES, hold eyelids open and flush with plenty of water.
IF SWALLOWED and victim is CONSCIOUS, have victim drink water or milk and have victim induce vomiting.
IF SWALLOWED and victim is UNCONSCIOUS OR HAVING CONVULSIONS, do nothing except keep victim warm.

Water Pollution

Dangerous to aquatic life in high concentrations.
May be dangerous if it enters water intakes.
Notify local health and wildlife officials.
Notify operators of nearby water intakes.

1. RESPONSE TO DISCHARGE

(See Response Methods Handbook, CG 446-4)

Issue warning - high flammability
Restrict access
Evacuate area
Disperse and flush

2. LABEL

Red

3. CHEMICAL DESIGNATIONS

3.1 **Synonyms:** Colonial spirit, Columbian spirit, Methanol, Wood alcohol, Wood naphtha, Wood spirit

3.2 **Coast Guard Compatibility Classification:** Alcohol

3.3 **Chemical Formula:** CH_3OH

3.4 **IMCO/United Nations Numerical Designation:** 3.2/1230

4. OBSERVABLE CHARACTERISTICS

4.1 **Physical State (as shipped):** Liquid

4.2 **Color:** Colorless

4.3 **Odor:** Faint alcohol; like ethyl alcohol; faintly sweet, characteristic pungent

5. HEALTH HAZARDS

5.1 **Personal Protective Equipment:** Approved canister mask for high vapor concentrations; safety goggles; rubber gloves

5.2 **Symptoms Following Exposure:** Exposure to excessive vapor causes eye irritation, headache, fatigue and drowsiness. High concentrations can produce central nervous system depression and optic nerve damage. 50,000 ppm will probably cause death in 1 to 2 hrs. Can be absorbed through skin. Swallowing may cause death or eye damage.

5.3 **Treatment for Exposure:** Remove victim from exposure and apply artifical respiration if breathing has ceased. INGESTION: induce vomiting, then give 2 teaspoons of baking soda in glass of water; call a physician. SKIN OR EYES: flush with water for 15 min.

5.4 **Toxicity by Inhalation (Threshold Limit Value):** 200 ppm

5.5 **Short-Term Inhalation Limits:** 260 mg/m^3 for 60 min.

5.6 **Toxicity by Ingestion:** Grade 1; 5 to 15 g/kg (rat)

5.7 **Late Toxicity:** None

5.8 **Vapor (Gas) Irritant Characteristics:** Vapors cause a slight smarting of the eyes or respiratory system if present in high concentrations. The effect is temporary.

5.9 **Liquid or Solid Irritant Characteristics:** Minimum hazard. If spilled on clothing and allowed to remain, may cause smarting and reddening of the skin.

5.10 **Odor Threshold:** 100 ppm

6. FIRE HAZARDS

6.1 **Flash Point:** 54°F C.C. - 61°F O.C.

6.2 **Flammable Limits in Air:** 6.0% - 36.5%

6.3 **Fire Extinguishing Agents:** Alcohol foam, dry chemical, or carbon dioxide

6.4 **Fire Extinguishing Agents Not to be Used:** Water may be ineffective

6.5 **Special Hazards of Combustion Products:** Not pertinent

6.6 **Behavior in Fire:** Containers may explode

6.7 **Ignition Temperature:** 867°F

6.8 **Electrical Hazard:** Class I, Group D

6.9 **Burning Rate:** 1.7 mm/min

7. CHEMICAL REACTIVITY

7.1 **Reactivity with Water:** No reaction

7.2 **Reactivity with Common Materials:** No reaction

7.3 **Stability During Transport:** Stable

7.4 **Neutralizing Agents for Acids and Caustics:** Not pertinent

7.5 **Polymerization:** Not pertinent

7.6 **Inhibitor of Polymerization:** Not pertinent

8. WATER POLLUTION

8.1 **Aquatic Toxicity:** 250 ppm/11 hr/goldfish/died/fresh water

8.2 **Waterfowl Toxicity:** Data not available

8.3 **Biological Oxygen Demand (BOD):** 0.6 to 1.12 lb/lb in 5 days

8.4 **Food Chain Concentration Potential:** None

9. SELECTED MANUFACTURERS

1. Borden Inc.
Borden Chemical Division
Geismar, La. 70734
2. Celanese Corp.
Celanese Chemical Co. Division
245 Park Ave.
New York, N. Y. 10017
3. E. I. du Pont de Nemours & Co., Inc.
Industrial and Biochemical Dept.
Wilmington, Del. 19898

10. SHIPPING INFORMATION

10.1 **Grades or Purity:** C.P., Crude, A.C.S. all 99.9%

10.2 **Storage Temperature:** Ambient

10.3 **Inert Atmosphere:** No requirement

10.4 **Venting:** Open (flame arrester) or pressure vacuum

11. HAZARD ASSESSMENT CODE

(See Hazard Assessment Handbook, CG 446-3)

A-P-Q-R-S

12. HAZARD CLASSIFICATIONS

12.1 **Code of Federal Regulations:** Flammable liquid

12.2 **NAS Hazard Rating for Bulk Water Transportation:**

Category	Rating
Fire	3
Health	
Vapor Irritant	1
Liquid or Solid Irritant	1
Poisons	2
Water Pollution	
Human Toxicity	1
Aquatic Toxicity	1
Aesthetic Effect	1
Reactivity	
Other Chemicals	2
Water	0
Self-Reaction	0

12.3 **NFPA Hazard Classifications:**

Category	Classification
Health Hazard (Blue)	1
Flammability (Red)	3
Reactivity (Yellow)	0

13. PHYSICAL AND CHEMICAL PROPERTIES

13.1 **Physical State at 15°C and 1 atm:** Liquid

13.2 **Molecular Weight:** 32.04

13.3 **Boiling Point at 1 atm:** 148.1°F = 64.5°C = 337.7°K

13.4 **Freezing Point:** −144.0°F = −97.8°C = 175.4°K

13.5 **Critical Temperature:** 464°F = 240°C = 513°K

13.6 **Critical Pressure:** 1142.0 psia = 77.7 atm = 7.87 MN/m^2

13.7 **Specific Gravity:** 0.792 at 20°C (liquid)

13.8 **Liquid Surface Tension:** Not pertinent

13.9 **Liquid-Water Interfacial Tension:** Not pertinent

13.10 **Vapor (Gas) Specific Gravity:** 1.1

13.11 **Ratio of Specific Heats of Vapor (Gas):** 1.254

13.12 **Latent Heat of Vaporization:** 473.0 Btu/lb = 262.8 cal/g = 11.00×10^5 J/kg

13.13 **Heat of Combustion:** −8419 Btu/lb = −4677 cal/g = -195.8×10^5 J/kg

13.14 **Heat of Decomposition:** Not pertinent

13.15 **Heat of Solution:** (est.) −9 Btu/lb = −5 cal/g = -0.2×10^5 J/kg

13.16 **Heat of Polymerization:** Not pertinent

NOTES

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TTE

TETRACHLOROETHYLENE

Common Synonyms
Tetracap
Perclene
Perchloroethylene

Watery liquid | Colorless | Sweet odor

Sinks in water. Irritating vapor is produced.

Stop discharge if possible.
Avoid contact with liquid and vapor.
Isolate and remove discharged material.
Notify local health and pollution control agencies.

Fire

Not flammable.
Poisonous gases are produced when heated.

Exposure

CALL FOR MEDICAL AID.

VAPOR
Irritating to eyes, nose, and throat.
If inhaled, will cause difficult breathing, or loss of consciousness.
Move to fresh air.
If breathing has stopped, give artificial respiration.
If breathing is difficult, give oxygen.

LIQUID
Irritating to skin and eyes.
Harmful if swallowed.
Remove contaminated clothing and shoes.
Flush affected areas with plenty of water.
IF IN EYES, hold eyelids open and flush with plenty of water.
IF SWALLOWED and victim is CONSCIOUS, have victim drink water or milk.

Water Pollution

Effect of low concentrations on aquatic life is unknown.
May be dangerous if it enters water intakes.
Notify local health and wildlife officials.
Notify operators of nearby water intakes.

1. RESPONSE TO DISCHARGE

(See Response Methods Handbook. CG 446-4)

Should be removed.
Chemical and physical treatment.

2. LABELS

No hazard label required by Code of Federal Regulations.

3. CHEMICAL DESIGNATIONS

3.1 **Synonyms:** Perchloroethylene, Perclene, Perk
3.2 **Coast Guard Compatibility Classification:** Halogenated hydrocarbon
3.3 **Chemical Formula:** $Cl_2C{=}CCl_2$
3.4 **IMCO/United Nations Numerical Designation:** 9.0, 1897

4. OBSERVABLE CHARACTERISTICS

4.1 **Physical State (as shipped):** Liquid
4.2 **Color:** Colorless
4.3 **Odor:** Ethereal, like chloroform, mildly sweet

5. HEALTH HAZARDS

5.1 **Personal Protective Equipment:** For high vapor concentrations use approved canister or air-supplied mask, chemical goggles or face shield, plastic gloves.
5.2 **Symptoms Following Exposure:** Vapor can affect central nervous system and cause anesthesia. Liquid may irritate skin after prolonged contact. May irritate eyes but causes no injury.
5.3 **Treatment for Exposure:** INHALATION: if illness occurs, remove patient to fresh air, keep him warm and quiet, and get medical attention. INGESTION: induce vomiting only on physician's recommendation. EYES AND SKIN: flush with plenty of water and get medical attention if irritation or injury occurs.
5.4 **Toxicity by Inhalation (Threshold Limit Value):** 100 ppm
5.5 **Short-Term Inhalation Limits:** 100 ppm for 60 min.
5.6 **Toxicity by Ingestion:** Grade 2; LD_{50} 0.5 to 5 g/kg
5.7 **Late Toxicity:** None
5.8 **Vapor (Gas) Irritant Characteristics:** Vapors cause a slight smarting of the eyes or throat if present in high concentrations. The effect is temporary.
5.9 **Liquid or Solid Irritant Characteristics:** Minimum hazard. If spilled on clothing and allowed to remain, may cause smarting and reddening of the skin.
5.10 **Odor Threshold:** 5 ppm

6. FIRE HAZARDS

6.1 **Flash Point:** Not flammable.
6.2 **Flammable Limits in Air:** Not flammable.
6.3 **Fire Extinguishing Agents:** Not pertinent.
6.4 **Fire Extinguishing Agents Not to be Used:** Not pertinent.
6.5 **Special Hazards of Combustion Products:** Toxic irritating gases may be generated in fires.
6.6 **Behavior in Fire:** Not pertinent.
6.7 **Ignition Temperature:** Not flammable.
6.8 **Electrical Hazard:** Not pertinent.
6.9 **Burning Rate:** Not flammable.

7. CHEMICAL REACTIVITY

7.1 **Reactivity with Water:** No reaction.
7.2 **Reactivity with Common Materials:** No reaction.
7.3 **Stability During Transport:** Stable.
7.4 **Neutralizing Agents for Acids and Caustics:** Not pertinent.
7.5 **Polymerization:** Not pertinent.
7.6 **Inhibitor of Polymerization:** Not pertinent.

8. WATER POLLUTION

8.1 **Aquatic Toxicity:** Data not available.
8.2 **Waterfowl Toxicity:** Data not available.
8.3 **Biological Oxygen Demand (BOD):** None.
8.4 **Food Chain Concentration Potential:** None.

9. SELECTED MANUFACTURERS

1. Dow Chemical Co.
Midland, Mich. 48640
2. PPG Industries Inc.
Industrial Chemical Division
Barberton, Ohio 44203
3. Vulcan Materials Co.
Chemicals Division
Wichita, Kan. 67201

10. SHIPPING INFORMATION

10.1 **Grades of Purity:** Dry cleaning and industrial grades, 99+%.
10.2 **Storage Temperature:** Ambient.
10.3 **Inert Atmosphere:** No requirement.
10.4 **Venting:** Pressure-vacuum.

11. HAZARD ASSESSMENT CODE

(See Hazard Assessment Handbook. CG 446-3)

A X

12. HAZARD CLASSIFICATIONS

12.1 **Code of Federal Regulations:** ORM-A
12.2 **NAS Hazard Rating for Bulk Water Transportation:**

Category	Rating
Fire	0
Health	
Vapor Irritant	1
Liquid or Solid Irritant	1
Poisons	2
Water Pollution	
Human Toxicity	1
Aquatic Toxicity	3
Aesthetic Effect	2
Reactivity	
Other Chemicals	1
Water	0
Self-Reaction	1

12.3 **NFPA Hazard Classifications:** Not listed.

13. PHYSICAL AND CHEMICAL PROPERTIES

13.1 **Physical State at 15°C and 1 atm:** Liquid
13.2 **Molecular Weight:** 165.83
13.3 **Boiling Point at 1 atm:** 250°F = 121°C = 394°K
13.4 **Freezing Point:** −8.3°F = −22.4°C = 250.8°K
13.5 **Critical Temperature:** 657°F = 347°C = 620°K
13.6 **Critical Pressure:** Not pertinent.
13.7 **Specific Gravity:** 1.63 at 20°C (liquid)
13.8 **Liquid Surface Tension:** 31.3 dynes/cm = 0.0313 N/m at 20°C
13.9 **Liquid-Water Interfacial Tension:** 44.4 dynes/cm = 0.0444 N/m at 25°C
13.10 **Vapor (Gas) Specific Gravity:** Not pertinent.
13.11 **Ratio of Specific Heats of Vapor (Gas):** 1.116
13.12 **Latent Heat of Vaporization:** 90.2 Btu/lb = 50.1 cal/g = 2.10×10^5 J/kg
13.13 **Heat of Combustion:** Not pertinent.
13.14 **Heat of Decomposition:** Not pertinent.
13.15 **Heat of Solution:** Not pertinent.
13.16 **Heat of Polymerization:** Not pertinent.

NOTES

REVISED 1978

TOL

TOLUENE

Common Synonyms
Toluol
Methylbenzene
Methylbenzol

Watery liquid | Colorless | Pleasant odor

Floats on water. Flammable, irritating vapor is produced.

Stop discharge if possible. Keep people away
Shut off ignition sources and call fire department
Stay upwind and use water spray to "knock down" vapor
Avoid contact with liquid and vapor
Isolate and remove discharged material
Notify local health and pollution control agencies

Fire

FLAMMABLE.
Flashback along vapor trail may occur
Vapor may explode if ignited in an enclosed area
Wear goggles and self-contained breathing apparatus
Extinguish with dry chemical, foam, or carbon dioxide
Water may be ineffective on fire
Cool exposed containers with water

Exposure

CALL FOR MEDICAL AID

VAPOR
Irritating to eyes, nose and throat
If inhaled, will cause nausea, vomiting, headache, dizziness, difficult breathing, or loss of consciousness
Move to fresh air
If breathing has stopped, give artificial respiration
If breathing difficult, give oxygen

LIQUID
Irritating to skin and eyes
If swallowed, will cause nausea, vomiting or loss of consciousness
Remove contaminated clothing and shoes
Flush affected areas with plenty of water
IF IN EYES, hold eyelids open and flush with plenty of water
IF SWALLOWED and victim is CONSCIOUS, have victim drink water or milk
DO NOT INDUCE VOMITING.

Water Pollution

Dangerous to aquatic life in high concentrations
Fouling to shoreline
May be dangerous if it enters water intakes
Notify local health and wildlife officials
Notify operators of nearby water intakes

1. RESPONSE TO DISCHARGE

(See Response Methods Handbook, CG 446-4)

Issue warning - high flammability
Evacuate area

2. LABEL

Red

3. CHEMICAL DESIGNATIONS

3.1 **Synonyms:** Methylbenzene, Methylbenzol, Toluol

3.2 **Coast Guard Compatibility Classification:** Aromatic hydrocarbon

3.3 **Chemical Formula:** $C_6H_5CH_3$

3.4 **IMCO/United Nations Numerical Designation:** 3.2/1294

4. OBSERVABLE CHARACTERISTICS

4.1 **Physical State (as shipped):** Liquid

4.2 **Color:** Colorless

4.3 **Odor:** Pungent, aromatic, benzene-like, distinct, pleasant

5. HEALTH HAZARDS

5.1 **Personal Protective Equipment:** Air-supplied mask, goggles or face shield, plastic gloves

5.2 **Symptoms Following Exposure:** Vapors irritate eyes and upper respiratory tract, cause dizziness, headache, anesthesia, respiratory arrest. Liquid irritates eyes and causes drying of skin. If aspirated, causes coughing, gagging, distress, and rapidly developing pulmonary edema. If ingested causes vomiting, griping, diarrhea, depressed respiration.

5.3 **Treatment for Exposure:** INHALATION: remove to fresh air, give artificial respiration and oxygen if needed, call a doctor. INGESTION: do NOT induce vomiting; call a doctor. EYES: flush with water for at least 15 min. SKIN: wipe off, wash with soap and water.

5.4 **Toxicity by Inhalation (Threshold Limit Value):** 100 ppm

5.5 **Short-Term Inhalation Limits:** 600 ppm for 30 min

5.6 **Toxicity by Ingestion:** Grade 2, LD_{50} 0.5 to 5 g/kg

5.7 **Late Toxicity:** Kidney and liver damage may follow ingestion

5.8 **Vapor (Gas) Irritant Characteristics:** Vapors cause a slight smarting of the eyes or respiratory system if present in high concentrations. The effect is temporary.

5.9 **Liquid or Solid Irritant Characteristics:** Minimum hazard. If spilled on clothing and allowed to remain, may cause smarting and reddening of the skin.

5.10 **Odor Threshold:** 0.17 ppm

6. FIRE HAZARDS

6.1 **Flash Point:** 40°F C.C. = 5°F O.C.

6.2 **Flammable Limits in Air:** 1.27% - 7%

6.3 **Fire Extinguishing Agents:** Carbon dioxide or dry chemical for small fires, ordinary foam for large fires.

6.4 **Fire Extinguishing Agents Not to be Used:** Water may be ineffective.

6.5 **Special Hazards of Combustion Products:** Not pertinent.

6.6 **Behavior in Fire:** Vapor is heavier than air and may travel a considerable distance to a source of ignition and flash back.

6.7 **Ignition Temperature:** 997°F

6.8 **Electrical Hazard:** Class I, Group D

6.9 **Burning Rate:** 5.7 mm/min

7. CHEMICAL REACTIVITY

7.1 **Reactivity with Water:** No reaction

7.2 **Reactivity with Common Materials:** No reaction

7.3 **Stability During Transport:** Stable

7.4 **Neutralizing Agents for Acids and Caustics:** Not pertinent

7.5 **Polymerization:** Not pertinent

7.6 **Inhibitor of Polymerization:** Not pertinent

8. WATER POLLUTION

8.1 **Aquatic Toxicity:** 1150 mg/l - 96 hr, sunfish; 11 mg/l fresh water

8.2 **Waterfowl Toxicity:** Data not available

8.3 **Biological Oxygen Demand (BOD):** 0% - 5 days, 38% (theor.), 8 days

8.4 **Food Chain Concentration Potential:** None

9. SELECTED MANUFACTURERS

1. Exxon Chemical Co.
Houston, Tex. 77001

2. Shell Chemical Co.
Petrochemicals Division
Houston, Tex. 77001

3. Sun Oil Co.
St. Davids, Pa. 19087

10. SHIPPING INFORMATION

10.1 **Grades or Purity:** Research reagent, nitration - all 99.8+%; industrial contains 94+% with C8 xylene and small amounts of benzene and nonaromatic hydrocarbons; 90/120 less pure than industrial

10.2 **Storage Temperature:** Ambient

10.3 **Inert Atmosphere:** No requirement

10.4 **Venting:** Open (flame arrester) or pressure-vacuum

11. HAZARD ASSESSMENT CODE

(See Hazard Assessment Handbook, CG 446-3)

A-T-C

12. HAZARD CLASSIFICATIONS

12.1 **Code of Federal Regulations:** Flammable liquid

12.2 **NAS Hazard Rating for Bulk Water Transportation:**

Category	Rating
Fire	3
Health	
Vapor Irritant	1
Liquid or Solid Irritant	1
Poisons	2
Water Pollution	
Human Toxicity	1
Aquatic Toxicity	3
Aesthetic Effect	2
Reactivity	
Other Chemicals	1
Water	0
Self-Reaction	0

12.3 **NFPA Hazard Classifications:**

Category	Classification
Health Hazard (Blue)	2
Flammability (Red)	3
Reactivity (Yellow)	0

13. PHYSICAL AND CHEMICAL PROPERTIES

13.1 **Physical State at 15°C and 1 atm:** Liquid

13.2 **Molecular Weight:** 92.14

13.3 **Boiling Point at 1 atm:** 231.1°F = 110.6°C = 383.8°K

13.4 **Freezing Point:** −139°F = −95.0°C = 178.2°K

13.5 **Critical Temperature:** 605.4°F = 318.6°C = 591.8°K

13.6 **Critical Pressure:** 596.1 psia = 40.55 atm = 4.108 MN/m²

13.7 **Specific Gravity:** 0.867 at 20°C (liquid)

13.8 **Liquid Surface Tension:** 29.0 dynes/cm = 0.0290 N/m at 20°C

13.9 **Liquid-Water Interfacial Tension:** 36.1 dynes/cm = 0.0361 N/m at 25°C

13.10 **Vapor (Gas) Specific Gravity:** Not pertinent

13.11 **Ratio of Specific Heats of Vapor (Gas):** 1.089

13.12 **Latent Heat of Vaporization:** 155 Btu/lb = 86.1 cal/g = 3.61×10^5 J/kg

13.13 **Heat of Combustion:** −17,430 Btu/lb = −9686 cal/g = -405.5×10^5 J/kg

13.14 **Heat of Decomposition:** Not pertinent

13.15 **Heat of Solution:** Not pertinent

13.16 **Heat of Polymerization:** Not pertinent

NOTES

REVISED 1978

TCL

TRICHLOROETHYLENE

Common Synonyms
Trichloroethene
Trilene

Watery liquid | Colorless | Sweet odor

Sinks in water. Irritating vapor is produced.

Stop discharge if possible. Keep people away.
Avoid contact with liquid and vapor.
Call fire department.
Isolate and remove discharged material.
Notify local health and pollution control agencies.

Fire

Combustible.
POISONOUS GASES ARE PRODUCED IN FIRE.
Wear goggles and self-contained breathing apparatus.
Extinguish with dry chemical, carbon dioxide, or foam.

Exposure

CALL FOR MEDICAL AID.

VAPOR
Irritating to eyes, nose and throat.
If inhaled, will cause nausea, vomiting, difficult breathing or loss of consciousness.
Move to fresh air.
If breathing has stopped, give artificial respiration.
If breathing is difficult, give oxygen.

LIQUID
Irritating to skin and eyes.
If swallowed, will cause nausea, vomiting, difficult breathing, or loss of consciousness.
Remove contaminated clothing and shoes.
Flush affected areas with plenty of water.
IF IN EYES, hold eyelids open and flush with plenty of water.
IF SWALLOWED and victim is CONSCIOUS, have victim drink water or milk and have victim induce vomiting.
IF SWALLOWED and victim is UNCONSCIOUS OR HAVING CONVULSIONS, do nothing except keep victim warm.

Water Pollution

Effect of low concentrations on aquatic life is unknown.
May be dangerous if it enters water intakes.
Notify local health and wildlife officials.
Notify operators of nearby water intakes.

1. RESPONSE TO DISCHARGE

(See Response Methods Handbook, CG 446-4)

Should be removed
Chemical and physical treatment

2. LABELS

No hazard label required by Code of Federal Regulations

3. CHEMICAL DESIGNATIONS

3.1 **Synonyms:** Algylen; Chlorylen; Gemalgene; Threthylene; Trethylene; Tri; Trichloran; Trichloroethene; Tri-Clene; Triclene; Trilene; Triline; Trimar

3.2 **Coast Guard Compatibility Classification:** Halogenated hydrocarbon

3.3 **Chemical Formula:** $CHCl{=}CCl_2$

3.4 **IMCO/United Nations Numerical Designation:** 9.0/1710

4. OBSERVABLE CHARACTERISTICS

4.1 **Physical State (as shipped):** Liquid

4.2 **Color:** Colorless

4.3 **Odor:** Chloroform-like, ethereal

5. HEALTH HAZARDS

5.1 **Personal Protective Equipment:** Organic vapor-acid gas canister; self-contained breathing apparatus for emergencies; neoprene or vinyl gloves, chemical safety goggles, face-shield, neoprene safety shoes, neoprene suit or apron for splash protection.

5.2 **Symptoms Following Exposure:** INHALATION: symptoms range from irritation of the nose and throat to nausea, an attitude of irresponsibility, blurred vision, and finally disturbance of central nervous system resulting in cardiac failure. Chronic exposure may cause organic injury. INGESTION: symptoms similar to inhalation. SKIN: defatting action can cause dermatitis. EYES: slightly irritating sensation and lachrymation.

5.3 **Treatment for Exposure:** Do NOT administer adrenalin or epinephrine; get medical attention for all cases of overexposure. INHALATION: remove victim to fresh air; if necessary, apply artificial respiration and/or administer oxygen. INGESTION: have victim drink water and induce vomiting; repeat three times, then give 1 tablespoon epsom salts in water. EYES: flush thoroughly with water. SKIN: wash thoroughly with soap and warm water.

5.4 **Toxicity by Inhalation (Threshold Limit Value):** 100 ppm

5.5 **Short-Term Inhalation Limits:** 200 ppm for 30 min

5.6 **Toxicity by Ingestion:** Grade 3; LD_{50} 50 to 500 mg/kg

5.7 **Late Toxicity:** Data not available

5.8 **Vapor (Gas) Irritant Characteristics:** Vapors cause a slight smarting of the eyes or respiratory system if present in high concentrations. The effect is temporary.

5.9 **Liquid or Solid Irritant Characteristics:** Minimum hazard. If spilled on clothing and allowed to remain, may cause smarting and reddening of the skin.

5.10 **Odor Threshold:** 50 ppm

6. FIRE HAZARDS

6.1 **Flash Point:** 90°F C.C. (practically nonflammable)

6.2 **Flammable Limits in Air:** 8.0% - 10.5%

6.3 **Fire Extinguishing Agents:** Water fog

6.4 **Fire Extinguishing Agents Not to be Used:** Not pertinent

6.5 **Special Hazards of Combustion Products:** Toxic and irritating gases are produced in fire situations.

6.6 **Behavior in Fire:** Not pertinent

6.7 **Ignition Temperature:** 770 °F

6.8 **Electrical Hazard:** Not pertinent

6.9 **Burning Rate:** Not pertinent

7. CHEMICAL REACTIVITY

7.1 **Reactivity with Water:** No reaction

7.2 **Reactivity with Common Materials:** No reaction

7.3 **Stability During Transport:** Stable

7.4 **Neutralizing Agents for Acids and Caustics:** Not pertinent

7.5 **Polymerization:** Not pertinent

7.6 **Inhibitor of Polymerization:** Not pertinent

8. WATER POLLUTION

8.1 **Aquatic Toxicity:** 660 mg/l/48 hr-daphnia-fair fresh water

8.2 **Waterfowl Toxicity:** Data not available

8.3 **Biological Oxygen Demand (BOD):** Data not available

8.4 **Food Chain Concentration Potential:** None

9. SELECTED MANUFACTURERS

1. Dow Chemical Co.
Midland, Mich. 48640
2. E. I. duPont de Nemours & Co., Inc.
Electrochemicals Dept.
Wilmington, Del. 19898
3. PPG Industries Inc.
Industrial Chemical Division
Lake Charles, La. 70601

10. SHIPPING INFORMATION

10.1 **Grades or Purity:** Technical; dry cleaning; degreasing; extraction

10.2 **Storage Temperature:** Ambient

10.3 **Inert Atmosphere:** No requirement

10.4 **Venting:** Pressure-vacuum

11. HAZARD ASSESSMENT CODE

(See Hazard Assessment Handbook, CG 446-3)

A-X-Y

12. HAZARD CLASSIFICATIONS

12.1 **Code of Federal Regulations:** ORM-A

12.2 **NAS Hazard Rating for Bulk Water Transportation:**

Category	Rating
Fire	1
Health	
Vapor Irritant	1
Liquid or Solid Irritant	1
Poisons	2
Water Pollution	
Human Toxicity	1
Aquatic Toxicity	2
Aesthetic Effect	2
Reactivity	
Other Chemicals	1
Water	0
Self-Reaction	1

12.3 **NFPA Hazard Classifications:** Not listed

13. PHYSICAL AND CHEMICAL PROPERTIES

13.1 **Physical State at 15°C and 1 atm:** Liquid

13.2 **Molecular Weight:** 131.39

13.3 **Boiling Point at 1 atm:** 189°F = 87°C = 360°K

13.4 **Freezing Point:** −123.5°F = −86.4°C = 186.8°K

13.5 **Critical Temperature:** Not pertinent

13.6 **Critical Pressure:** Not pertinent

13.7 **Specific Gravity:** 1.46 at 20°C (liquid)

13.8 **Liquid Surface Tension:** 29.3 dynes/cm = 0.0293 N/m at 20°C

13.9 **Liquid-Water Interfacial Tension:** 34.5 dynes/cm = 0.0345 N/m at 24°C

13.10 **Vapor (Gas) Specific Gravity:** 4.5

13.11 **Ratio of Specific Heats of Vapor (Gas):** 1.116

13.12 **Latent Heat of Vaporization:** 103 Btu/lb = 57.2 cal/g = 2.40×10^5 J/kg

13.13 **Heat of Combustion:** Not pertinent

13.14 **Heat of Decomposition:** Not pertinent

13.15 **Heat of Solution:** Not pertinent

13.16 **Heat of Polymerization:** Not pertinent

NOTES

REVISED 1978

VCM — VINYL CHLORIDE

Common Synonyms
Chloroethylene
VCL
Vinyl C Monomer

Liquefied compressed gas. Colorless. Sweet odor.

Liquid floats and boils on water. Flammable, irritating visible vapor cloud is produced.

Stop discharge if possible. Keep people away.
Shut off ignition sources and call fire department.
Stay upwind and use water spray to "knock down" vapor.
Evacuate area in case of large discharge.
Avoid contact with liquid and vapor.
Notify local health and pollution control agencies.

Fire

FLAMMABLE.
POISONOUS GAS IS PRODUCED IN FIRE.
Flashback along vapor trail may occur.
May explode if ignited in an enclosed area.
Wear self-contained breathing apparatus.
Cool exposed containers and protect men effecting shutoff with water.
Stop flow of gas if possible.
Let fire burn.
Extinguish small fires with dry chemical.

Exposure

CALL FOR MEDICAL AID.

VAPOR
Irritating to eyes, nose, and throat.
If inhaled, will cause dizziness or difficult breathing.
Move to fresh air.
If breathing has stopped, give artificial respiration.
If breathing is difficult, give oxygen.

LIQUID
Will cause frostbite.
Flush affected areas with plenty of water.
DO NOT RUB AFFECTED AREAS.

Water Pollution

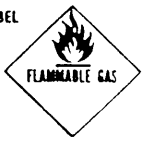
Not harmful to aquatic life.

1. RESPONSE TO DISCHARGE

(See Response Methods Handbook, CG 446-4)

Issue warning: high flammability.
Evacuate area.

2. LABEL



Red

3. CHEMICAL DESIGNATIONS

3.1 **Synonyms:** Chloroethene
Chloroethylene
Vinyl C Monomer
VCL
VCM

3.2 **Coast Guard Compatibility Classification:** Vinyl halides

3.3 **Chemical Formula:** $CH_2=CHCl$

3.4 **IMCO/United Nations Numerical Designation:** 20/1086

4. OBSERVABLE CHARACTERISTICS

4.1 **Physical State (as shipped):** Liquefied gas

4.2 **Color:** Colorless

4.3 **Odor:** Pleasant, sweet

5. HEALTH HAZARDS

5.1 **Personal Protective Equipment:** Rubber gloves and shoes; gas-tight goggles; organic vapor canister or self-contained breathing apparatus

5.2 **Symptoms Following Exposure:** INHALATION: high concentrations cause dizziness, anesthesia, lung irritation. SKIN: may cause frostbite; phenol inhibitor may be absorbed through skin if large amounts of liquid evaporate.

5.3 **Treatment for Exposure:** INHALATION: remove patient to fresh air and keep him quiet and warm; call a doctor; give artificial respiration if breathing stops. EYES AND SKIN: flush with plenty of water for at least 15 min.; for eyes, get medical attention; remove contaminated clothing.

5.4 **Toxicity by Inhalation (Threshold Limit Value):** 200 ppm

5.5 **Short-Term Inhalation Limits:** 500 ppm for 5 min.

5.6 **Toxicity by Ingestion:** Not pertinent

5.7 **Late Toxicity:** Chronic exposure may cause liver damage.

5.8 **Vapor (Gas) Irritant Characteristics:** Vapors cause moderate irritation such that personnel will find high concentrations unpleasant. The effect is temporary.

5.9 **Liquid or Solid Irritant Characteristics:** Minimum hazard. If spilled on clothing and allowed to remain, may cause smarting and reddening of skin. May cause frostbite.

5.10 **Odor Threshold:** 260 ppm

6. FIRE HAZARDS

6.1 **Flash Point:** −110°F, CC

6.2 **Flammable Limits in Air:** 4% - 26%

6.3 **Fire Extinguishing Agents:** For small fires use dry chemical or carbon dioxide. For large fires stop flow of gas. Cool exposed containers with water.

6.4 **Fire Extinguishing Agents Not to be Used:** Not pertinent.

6.5 **Special Hazards of Combustion Products:** Forms highly toxic combustion products such as hydrogen chloride, phosgene and carbon monoxide.

6.6 **Behavior in Fire:** Container may explode in fire. Gas is heavier than air and may travel considerable distance to a source of ignition and flash back.

6.7 **Ignition Temperature:** 882°F

6.8 **Electrical Hazard:** Class I, Group D

6.9 **Burning Rate:** 4.3 mm/min.

7. CHEMICAL REACTIVITY

7.1 **Reactivity with Water:** No reaction.

7.2 **Reactivity with Common Materials:** No reaction.

7.3 **Stability During Transport:** Stable.

7.4 **Neutralizing Agents for Acids and Caustics:** Not pertinent.

7.5 **Polymerization:** Polymerizes in presence of air, sunlight, or heat unless stabilized by inhibitors.

7.6 **Inhibitor of Polymerization:** Not normally used except when high temperatures are expected. Then 40-100 ppm of phenol used.

8. WATER POLLUTION

8.1 **Aquatic Toxicity:** None

8.2 **Waterfowl Toxicity:** None

8.3 **Biological Oxygen Demand (BOD):** None

8.4 **Food Chain Concentration Potential:** None

9. SELECTED MANUFACTURERS

1. Dow Chemical Co.
Midland, Mich. 48640
2. The B. F. Goodrich Co.
6100 Oak Tree Blvd.
Cleveland, Ohio 44131
3. PPG Industries, Inc.
Chemical Division
Guayanilla, Puerto Rico 00656

10. SHIPPING INFORMATION

10.1 **Grades or Purity:** Commercial or technical 99+%

10.2 **Storage Temperature:** Under pressure: ambient
At atm. pressure: low

10.3 **Inert Atmosphere:** No requirement

10.4 **Venting:** Under pressure: safety relief
At atm. pressure: pressure-vacuum

11. HAZARD ASSESSMENT CODE

(See Hazard Assessment Handbook, CG 446-3)

A-B-C-D-E-F-G-Z

12. HAZARD CLASSIFICATIONS

12.1 **Code of Federal Regulations:** Flammable compressed gas

12.2 **NAS Hazard Rating for Bulk Water Transportation:**

Category	Rating
Fire	4
Health	
Vapor Irritant	2
Liquid or Solid Irritant	1
Poisons	2
Water Pollution	
Human Toxicity	0
Aquatic Toxicity	0
Aesthetic Effect	0
Reactivity	
Other Chemicals	2
Water	0
Self-Reaction	2

12.3 **NFPA Hazard Classifications:**

Category	Classification
Health Hazard (Blue)	2
Flammability (Red)	4
Reactivity (Yellow)	1

13. PHYSICAL AND CHEMICAL PROPERTIES

13.1 **Physical State at 15°C and 1 atm:** Gas

13.2 **Molecular Weight:** 62.50

13.3 **Boiling Point at 1 atm:** 7.2°F = −13.8°C = 259.4°K

13.4 **Freezing Point:** −244.8°F = −153.8°C = −119.4°K

13.5 **Critical Temperature:** 317.1°F = 158.4°C = 431.6°K

13.6 **Critical Pressure:** 775 psia = 52.7 atm = 5.34 MN/m²

13.7 **Specific Gravity:** 0.969 at −13°C (liquid)

13.8 **Liquid Surface Tension:** 16.0 dynes/cm = 0.0160 N/m at 25°C

13.9 **Liquid-Water Interfacial Tension:** (est.) 30 dynes/cm = 0.03 N/m at 20°C

13.10 **Vapor (Gas) Specific Gravity:** 2.2

13.11 **Ratio of Specific Heats of Vapor (Gas):** 1.186

13.12 **Latent Heat of Vaporization:** 160 Btu/lb = 88 cal/g = 3.7×10^5 J/kg

13.13 **Heat of Combustion:** −8136 Btu/lb = −4520 cal/g = -189.1×10^5 J/kg

13.14 **Heat of Decomposition:** Not pertinent

13.15 **Heat of Solution:** Not pertinent

13.16 **Heat of Polymerization:** −729 Btu/lb = −405 cal/g = -16.9×10^5 J/kg

NOTES

REVISED 1978

XLM	m-XYLENE

Common Synonyms
1,3-Dimethylbenzene
Xylol

Watery liquid Colorless Sweet odor

Floats on water. Flammable, irritating vapor is produced.

Stop discharge if possible. Keep people away.
Call fire department.
Avoid contact with liquid and vapor.
Isolate and remove discharged material.
Notify local health and pollution control agencies.

Fire

FLAMMABLE
Flashback along vapor trail may occur.
Vapor may explode if ignited in an enclosed area.
Wear self-contained breathing apparatus.
Extinguish with foam, dry chemical, or carbon dioxide.
Water may be ineffective on fire.
Cool exposed containers with water.

Exposure

CALL FOR MEDICAL AID
VAPOR
Irritating to eyes, nose, and throat.
If inhaled, will cause headache, difficult breathing, or loss of consciousness.
Move to fresh air.
If breathing has stopped, give artificial respiration.
If breathing is difficult, give oxygen.
LIQUID
Irritating to skin and eyes.
If swallowed, will cause nausea, vomiting, or loss of consciousness.
Remove contaminated clothing and shoes.
Flush affected areas with plenty of water.
IF IN EYES, hold eyelids open and flush with plenty of water.
IF SWALLOWED and victim is CONSCIOUS, have victim drink water or milk.
DO NOT INDUCE VOMITING.

Water Pollution

HARMFUL TO AQUATIC LIFE IN VERY LOW CONCENTRATIONS
Fouling to shoreline.
May be dangerous if it enters water intakes.
Notify local health and wildlife officials.
Notify operators of nearby water intakes.

1. RESPONSE TO DISCHARGE

(See Response Methods Handbook, CG 446-4)

Issue warning: high flammability
Evacuate area
Should be removed
Chemical and physical treatment

2. LABEL

Red

3. CHEMICAL DESIGNATIONS

3.1 **Synonyms:** 1,3-Dimethylbenzene; Xylol
3.2 **Coast Guard Compatibility Classification:** Aromatic hydrocarbon
3.3 **Chemical Formula:** m-$C_6H_4(CH_3)_2$
3.4 **IMCO/United Nations Numerical Designation:** 3.2/1307

4. OBSERVABLE CHARACTERISTICS

4.1 **Physical State (as shipped):** Liquid
4.2 **Color:** Colorless
4.3 **Odor:** Like benzene, characteristic aromatic

5. HEALTH HAZARDS

5.1 **Personal Protective Equipment:** Approved canister or air-supplied mask; goggles or face shield; plastic gloves and boots.
5.2 **Symptoms Following Exposure:** Vapors cause headache and dizziness. Liquid irritates eyes and skin. If taken into lungs, causes severe coughing, distress, and rapidly developing pulmonary edema. If ingested, causes nausea, vomiting, cramps, headache, and coma; can be fatal. Kidney and liver damage can occur.
5.3 **Treatment for Exposure:** INHALATION: remove to fresh air; administer artificial respiration and oxygen if required; call a doctor. INGESTION: do NOT induce vomiting; call a doctor. EYES: flush with water for at least 15 min. SKIN: wipe off, wash with soap and water.
5.4 **Toxicity by Inhalation (Threshold Limit Value):** 100 ppm
5.5 **Short-Term Inhalation Limits:** 300 ppm for 30 min
5.6 **Toxicity by Ingestion:** Grade 3, LD_{50} 50 to 500 g/kg
5.7 **Late Toxicity:** Kidney and liver damage
5.8 **Vapor (Gas) Irritant Characteristics:** Vapors cause a slight smarting of the eyes or respiratory system if present in high concentrations. The effect is temporary.
5.9 **Liquid or Solid Irritant Characteristics:** Minimum hazard. If spilled on clothing and allowed to remain, may cause smarting and reddening of the skin.
5.10 **Odor Threshold:** 0.05 ppm

6. FIRE HAZARDS

6.1 **Flash Point:** 84°F C.C.
6.2 **Flammable Limits in Air:** 1.1% - 6.4%
6.3 **Fire Extinguishing Agents:** Foam, dry chemical, or carbon dioxide
6.4 **Fire Extinguishing Agents Not to be Used:** Water may be ineffective
6.5 **Special Hazards of Combustion Products:** Not pertinent
6.6 **Behavior in Fire:** Vapor is heavier than air and may travel considerable distance to a source of ignition and flash back.
6.7 **Ignition Temperature:** 986°F
6.8 **Electrical Hazard:** Class I, Group D
6.9 **Burning Rate:** 3.5 mm/min

7. CHEMICAL REACTIVITY

7.1 **Reactivity with Water:** No reaction
7.2 **Reactivity with Common Materials:** No reaction
7.3 **Stability During Transport:** Stable
7.4 **Neutralizing Agents for Acids and Caustics:** Not pertinent
7.5 **Polymerization:** Not pertinent
7.6 **Inhibitor of Polymerization:** Not pertinent

8. WATER POLLUTION

8.1 **Aquatic Toxicity:** 23 ppm 96-hr Bioassay (Fresh water)
8.2 **Waterfowl Toxicity:** Data not available
8.3 **Biological Oxygen Demand (BOD):** 0.06 lb/lb, 5 days (Theoretical), 5 days
8.4 **Food Chain Concentration Potential:** Data not available

9. SELECTED MANUFACTURERS

1. ARCO Chemical Co.
260 South Broad St.
Philadelphia, Pa. 19101
2. Chevron Chemical Co.
Industrial Chemicals Division
200 Bush St.
San Francisco, Calif. 94120
3. Fallek Chemical Corp.
484 Park Ave.
New York, N.Y. 10022

10. SHIPPING INFORMATION

10.1 **Grades of Purity:** Research 99.99%, Pure 99.9%, Technical 99.2%
10.2 **Storage Temperature:** Ambient
10.3 **Inert Atmosphere:** Not required
10.4 **Venting:** Open (flame arrester or pressure-vacuum)

11. HAZARD ASSESSMENT CODE

(See Hazard Assessment Handbook, CG 446-3)

X.T.U.

12. HAZARD CLASSIFICATIONS

12.1 **Code of Federal Regulations:** Flammable liquid
12.2 **NAS Hazard Rating for Bulk Water Transportation:**

Category	Rating
Fire	3
Health	
Vapor Irritant	1
Liquid or Solid Irritant	1
Poisons	2
Water Pollution	
Human Toxicity	1
Aquatic Toxicity	3
Aesthetic Effect	2
Reactivity	
Other Chemicals	1
Water	0
Self-Reaction	0

12.3 **NFPA Hazard Classifications:**

Category	Classification
Health Hazard (Blue)	2
Flammability (Red)	3
Reactivity (Yellow)	0

13. PHYSICAL AND CHEMICAL PROPERTIES

13.1 **Physical State at 15°C and 1 atm:** Liquid
13.2 **Molecular Weight:** 106.16
13.3 **Boiling Point at 1 atm:** 269.4°F = 131.9°C = 405.1°K
13.4 **Freezing Point:** -54.2°F = -47.9°C = 225.3°K
13.5 **Critical Temperature:** 650.8°F = 343.8°C = 617.0°K
13.6 **Critical Pressure:** 513.8 atm = 34.95 psia = 3.540 MN/m²
13.7 **Specific Gravity:** 0.864 at 20°C (liquid)
13.8 **Liquid Surface Tension:** 28.6 dynes/cm = 0.0286 N/m at 20°C
13.9 **Liquid-Water Interfacial Tension:** 36.4 dynes/cm = 0.0364 N/m at 30°C
13.10 **Vapor (Gas) Specific Gravity:** Not pertinent
13.11 **Ratio of Specific Heats of Vapor (Gas):** 1.071
13.12 **Latent Heat of Vaporization:** 147 Btu/lb = 81.9 cal/g = 3.43×10^5 J/kg
13.13 **Heat of Combustion:** -17,554 Btu/lb = -9752.4 cal/g = -408.31×10^5 J/kg
13.14 **Heat of Decomposition:** Not pertinent
13.15 **Heat of Solution:** Not pertinent
13.16 **Heat of Polymerization:** Not pertinent

NOTES

REVISED 1978

XLO

o-XYLENE

Common Synonyms
1,2-Dimethylbenzene
Xylol

Watery liquid | Colorless | Sweet odor

Floats on water. Flammable, irritating vapor is produced.

Stop discharge if possible. Keep people away.
Call fire department.
Avoid contact with liquid and vapor.
Isolate and remove discharged material.
Notify local health and pollution control agencies.

Fire

FLAMMABLE.
Flashback along vapor trail may occur.
Vapor may explode if ignited in an enclosed area.
Wear self-contained breathing apparatus.
Extinguish with foam, dry chemical, or carbon dioxide.
Water may be ineffective on fire.
Cool exposed containers with water.

Exposure

CALL FOR MEDICAL AID.

VAPOR
Irritating to eyes, nose and throat.
If inhaled, will cause headache, difficult breathing, or loss of consciousness.
Move to fresh air.
If breathing has stopped, give artificial respiration.
If breathing is difficult, give oxygen.

LIQUID
Irritating to skin and eyes.
If swallowed, will cause nausea, vomiting, or loss of consciousness.
Remove contaminated clothing and shoes.
Flush affected areas with plenty of water.
IF IN EYES, hold eyelids open and flush with plenty of water.
IF SWALLOWED and victim is CONSCIOUS, have victim drink water or milk.
DO NOT INDUCE VOMITING.

Water Pollution

Dangerous to aquatic life in high concentrations.
Fouling to shoreline.
May be dangerous if it enters water intakes.
Notify local health and wildlife officials.
Notify operators of nearby water intakes.

1. RESPONSE TO DISCHARGE

(See Response Methods Handbook, CG 446-4)

Issue warning - high flammability
Evacuate area
Should be removed
Chemical and physical treatment

2. LABEL

Red

3. CHEMICAL DESIGNATIONS

3.1 **Synonyms:** 1,2-Dimethylbenzene
3.2 **Coast Guard Compatibility Classification:** Aromatic hydrocarbon
3.3 **Chemical Formula:** o-$C_6H_4(CH_3)_2$
3.4 **IMCO/United Nations Numerical Designation:** 3.2/1307

4. OBSERVABLE CHARACTERISTICS

4.1 **Physical State (as shipped):** Liquid
4.2 **Color:** Colorless
4.3 **Odor:** Benzene-like, characteristic aromatic

5. HEALTH HAZARDS

5.1 **Personal Protective Equipment:** Approved canister or air-supplied mask; goggles or face shield; plastic gloves and boots.
5.2 **Symptoms Following Exposure:** Vapors cause headache and dizziness. Liquid irritates eyes and skin. If taken into lungs, causes severe coughing, distress, and rapidly developing pulmonary edema. If ingested, causes nausea, vomiting, cramps, headache, and coma. Can be fatal. Kidney and liver damage can occur.
5.3 **Treatment for Exposure:** INHALATION: remove to fresh air; administer artificial respiration and oxygen if required; call a doctor. INGESTION: do NOT induce vomiting; call a doctor. EYES: flush with water for at least 15 min. SKIN: wipe off, wash with soap and water.
5.4 **Toxicity by Inhalation (Threshold Limit Value):** 100 ppm
5.5 **Short-Term Inhalation Limits:** 300 ppm for 30 min
5.6 **Toxicity by Ingestion:** Grade 3; LD_{50} 50 to 500 mg/kg
5.7 **Late Toxicity:** Kidney and liver damage
5.8 **Vapor (Gas) Irritant Characteristics:** Vapors cause a slight smarting of the eyes or respiratory system if present in high concentrations. The effect is temporary.
5.9 **Liquid or Solid Irritant Characteristics:** Minimum hazard. If spilled on clothing and allowed to remain, may cause smarting and reddening of the skin.
5.10 **Odor Threshold:** 0.05 ppm

6. FIRE HAZARDS

6.1 **Flash Point:** [illegible]
6.2 **Flammable Limits in Air:** [illegible]
6.3 **Fire Extinguishing Agents:** Foam, dry chemical, or carbon dioxide
6.4 **Fire Extinguishing Agents Not to be Used:** Water may be ineffective
6.5 **Special Hazards of Combustion Products:** Not pertinent
6.6 **Behavior in Fire:** Vapor is heavier than air and may travel considerable distance to a source of ignition and flash back
6.7 **Ignition Temperature:** 867°F
6.8 **Electrical Hazard:** Class I, Group D
6.9 **Burning Rate:** [illegible]

7. CHEMICAL REACTIVITY

7.1 **Reactivity with Water:** No reaction
7.2 **Reactivity with Common Materials:** No reaction
7.3 **Stability During Transport:** Stable
7.4 **Neutralizing Agents for Acids and Caustics:** Not pertinent
7.5 **Polymerization:** Not pertinent
7.6 **Inhibitor of Polymerization:** Not pertinent

8. WATER POLLUTION

8.1 **Aquatic Toxicity:** [illegible]
8.2 **Waterfowl Toxicity:** Data not available
8.3 **Biological Oxygen Demand (BOD):** [illegible]
8.4 **Food Chain Concentration Potential:** Data not available

9. SELECTED MANUFACTURERS

1. Atlantic Richfield Co.
ARCO Chemical Co. Division
260 South Broad St.
Philadelphia, Pa. 19101
2. Cities Service Co., Inc.
Petrochemicals Division
60 Wall St.
New York, N.Y. 10005
3. Shell Chemical Co.
Petrochemicals Division
Houston, Tex. 77001

10. SHIPPING INFORMATION

10.1 **Grades or Purity:** Research, 99.9%; Pure, 99.5%; Commercial, 95%
10.2 **Storage Temperature:** Ambient
10.3 **Inert Atmosphere:** Nitrogen blanket
10.4 **Venting:** Open flame arrester; pressure/vacuum

11. HAZARD ASSESSMENT CODE

(See Hazard Assessment Handbook, CG 446-3)

A.T.C.

12. HAZARD CLASSIFICATIONS

12.1 **Code of Federal Regulations:** Flammable liquid
12.2 **NAS Hazard Rating for Bulk Water Transportation:**

Category	Rating
Fire	3
Health	
Vapor Irritant	1
Liquid or Solid Irritant	1
Poisons	2
Water Pollution	
Human Toxicity	1
Aquatic Toxicity	3
Aesthetic Effect	2
Reactivity	
Other Chemicals	1
Water	0
Self-Reaction	0

12.3 **NFPA Hazard Classifications:**

Category	Classification
Health Hazard (Blue)	2
Flammability (Red)	3
Reactivity (Yellow)	0

13. PHYSICAL AND CHEMICAL PROPERTIES

13.1 **Physical State at 15°C and 1 atm:** Liquid
13.2 **Molecular Weight:** 106.16
13.3 **Boiling Point at 1 atm:** 291.9°F = 144.4°C = 417.6°K
13.4 **Freezing Point:** −13.3°F = −25.2°C = 248.0°K
13.5 **Critical Temperature:** 674.8°F = 357.1°C = 630.3°K
13.6 **Critical Pressure:** 541.5 atm = 36.84 psia = 3.732 MN/m²
13.7 **Specific Gravity:** 0.880 at 20°C (liquid)
13.8 **Liquid Surface Tension:** 30.53 dynes/cm = 0.03053 N/m at 15.5°C
13.9 **Liquid-Water Interfacial Tension:** 36.06 dynes/cm = 0.03606 N/m at 20°C
13.10 **Vapor (Gas) Specific Gravity:** Not pertinent
13.11 **Ratio of Specific Heats of Vapor (Gas):** 1.068
13.12 **Latent Heat of Vaporization:** 149 Btu/lb = 82.9 cal/g = 3.47 × 10⁵ J/kg
13.13 **Heat of Combustion:** −17,558 Btu/lb = −9754.7 cal/g = −408.41 × 10⁵ J/kg
13.14 **Heat of Decomposition:** Not pertinent
13.15 **Heat of Solution:** Not pertinent
13.16 **Heat of Polymerization:** Not pertinent

NOTES

REVISED 1978

XLP

p-XYLENE

Common Synonyms
1,4-Dimethylbenzene
Xylol

Watery liquid | Colorless | Sweet odor

Floats on water. Flammable; irritating vapor is produced.
Freezing point is 56°F.

Stop discharge if possible. Keep people away.
Call fire department.
Avoid contact with liquid and vapor.
Isolate and remove discharged material.
Notify local health and pollution control agencies.

Fire

FLAMMABLE.
Flashback along vapor trail may occur.
Vapor may explode if ignited in an enclosed area.
Wear self-contained breathing apparatus.
Extinguish with foam, dry chemical, or carbon dioxide.
Water may be ineffective on fire.
Cool exposed containers with water.

Exposure

CALL FOR MEDICAL AID.

VAPOR
Irritating to eyes, nose and throat.
If inhaled, will cause dizziness, difficult breathing, or loss of consciousness.
Move to fresh air.
If breathing has stopped, give artificial respiration.
If breathing is difficult, give oxygen.

LIQUID
Irritating to skin and eyes.
If swallowed, will cause nausea, vomiting, loss of consciousness.
Remove contaminated clothing and shoes.
Flush affected areas with plenty of water.
IF IN EYES, hold eyelids open and flush with plenty of water.
IF SWALLOWED and victim is CONSCIOUS, have victim drink water or milk.
DO NOT INDUCE VOMITING.

Water Pollution

HARMFUL TO AQUATIC LIFE IN VERY LOW CONCENTRATIONS.
Fouling to shoreline.
May be dangerous if it enters water intakes.
Notify local health and wildlife officials.
Notify operators of nearby water intakes.

1. RESPONSE TO DISCHARGE

(See Response Methods Handbook, CG 446-4)

Issue warning: high flammability
Evacuate area
Should be removed
Chemical and physical treatment

2. LABEL

Red

3. CHEMICAL DESIGNATIONS

3.1 **Synonyms:** 1,4-Dimethylbenzene

3.2 **Coast Guard Compatibility Classification:** Aromatic hydrocarbon

3.3 **Chemical Formula:** p-$C_6H_4(CH_3)_2$

3.4 **IMCO/United Nations Numerical Designation:** 3.2/1307

4. OBSERVABLE CHARACTERISTICS

4.1 **Physical State (as shipped):** Liquid

4.2 **Color:** Colorless

4.3 **Odor:** Like benzene, characteristic aromatic

5. HEALTH HAZARDS

5.1 **Personal Protective Equipment:** Approved canister or air-supplied mask, goggles or face shield, plastic gloves and boots.

5.2 **Symptoms Following Exposure:** Vapors cause headache and dizziness. Liquid irritates eyes and skin. If taken into lungs, causes severe coughing, distress, and rapidly developing pulmonary edema. If ingested, causes nausea, vomiting, cramps, headache, and coma. Can be fatal. Kidney and liver damage can occur.

5.3 **Treatment for Exposure:** INHALATION: remove to fresh air, administer artificial respiration and oxygen if required; call a doctor. INGESTION: do NOT induce vomiting; call a doctor. EYES: flush with water for at least 15 min. SKIN: wipe off, wash with soap and water.

5.4 **Toxicity by Inhalation (Threshold Limit Value):** 100 ppm

5.5 **Short-Term Inhalation Limits:** 300 ppm for 30 min

5.6 **Toxicity by Ingestion:** Grade 3; LD_{50} 50 to 500 mg/kg

5.7 **Late Toxicity:** Kidney and liver damage

5.8 **Vapor (Gas) Irritant Characteristics:** Vapors cause a slight smarting of the eyes or respiratory system if present in high concentrations. The effect is temporary.

5.9 **Liquid or Solid Irritant Characteristics:** Minimum hazard. If spilled on clothing and allowed to remain, may cause smarting and reddening of the skin.

5.10 **Odor Threshold:** 0.05 ppm

6. FIRE HAZARDS

6.1 **Flash Point:** 81°F C.C.

6.2 **Flammable Limits in Air:** 1.1% - 6.6%

6.3 **Fire Extinguishing Agents:** Foam, dry chemical, or carbon dioxide

6.4 **Fire Extinguishing Agents Not to be Used:** Water may be ineffective

6.5 **Special Hazards of Combustion Products:** Not pertinent

6.6 **Behavior in Fire:** Vapor is heavier than air and may travel considerable distance to a source of ignition and flash back.

6.7 **Ignition Temperature:** 870°F

6.8 **Electrical Hazard:** Class I, Group D

6.9 **Burning Rate:** 5.8 mm/min

7. CHEMICAL REACTIVITY

7.1 **Reactivity with Water:** No reaction

7.2 **Reactivity with Common Materials:** No reaction

7.3 **Stability During Transport:** Stable

7.4 **Neutralizing Agents for Acids and Caustics:** Not pertinent

7.5 **Polymerization:** Not pertinent

7.6 **Inhibitor of Polymerization:** Not pertinent

8. WATER POLLUTION

8.1 **Aquatic Toxicity:** 22 ppm/96 hr/bluegill/TLm/fresh water

8.2 **Waterfowl Toxicity:** Data not available

8.3 **Biological Oxygen Demand (BOD):** 0 lb/lb in 5 days

8.4 **Food Chain Concentration Potential:** Data not available

9. SELECTED MANUFACTURERS

1. Amoco Chemicals Corp
130 East Randolph Drive
Chicago, Ill. 60601
2. ARCO Chemical Co.
260 South Broad St.
Philadelphia, Pa. 19101
3. Chevron Chemical Co.
Industrial Chemicals Division
200 Bush St.
San Francisco, Calif. 94120

10. SHIPPING INFORMATION

10.1 **Grades or Purity:** Research: 99.99%
Pure: 99.9%; Technical: 99.0%

10.2 **Storage Temperature:** Ambient

10.3 **Inert Atmosphere:** No requirement

10.4 **Venting:** Open (flame arrester), or pressure-vacuum

11. HAZARD ASSESSMENT CODE

(See Hazard Assessment Handbook, CG 446-3)

A-T-U

12. HAZARD CLASSIFICATIONS

12.1 **Code of Federal Regulations:** Flammable liquid

12.2 **NAS Hazard Rating for Bulk Water Transportation:**

Category	Rating
Fire	3
Health	
Vapor Irritant	1
Liquid or Solid Irritant	1
Poisons	2
Water Pollution	
Human Toxicity	1
Aquatic Toxicity	3
Aesthetic Effect	2
Reactivity	
Other Chemicals	1
Water	0
Self-Reaction	0

12.3 **NFPA Hazard Classifications:**

Category	Classification
Health Hazard (Blue)	2
Flammability (Red)	3
Reactivity (Yellow)	0

13. PHYSICAL AND CHEMICAL PROPERTIES

13.1 **Physical State at 15°C and 1 atm:** Liquid

13.2 **Molecular Weight:** 106.16

13.3 **Boiling Point at 1 atm:** 280.9°F = 138.3°C = 411.5°K

13.4 **Freezing Point:** 55.9°F = 13.3°C = 286.5°K

13.5 **Critical Temperature:** 649.4°F = 343.0°C = 616.2°K

13.6 **Critical Pressure:** 509.4 atm = 34.65 psia = 3.510 MN/m²

13.7 **Specific Gravity:** 0.861 at 20°C (liquid)

13.8 **Liquid Surface Tension:** 28.3 dynes/cm = 0.0283 N/m at 20°C

13.9 **Liquid-Water Interfacial Tension:** 37.8 dynes/cm = 0.0378 N/m at 20°C

13.10 **Vapor (Gas) Specific Gravity:** Not pertinent

13.11 **Ratio of Specific Heats of Vapor (Gas):** 1.071

13.12 **Latent Heat of Vaporization:** 150 Btu/lb = 81 cal/g = 3.4×10^5 J/kg

13.13 **Heat of Combustion:** −17,559 Btu/lb = −9754.7 cal/g = -408.41×10^5 J/kg

13.14 **Heat of Decomposition:** Not pertinent

13.15 **Heat of Solution:** Not pertinent

13.16 **Heat of Polymerization:** Not pertinent

NOTES

REVISED 1978

ARSENIC

CAS NUMBER

7440-38-2

COMMON SYNONYMS

None.

ANALYTICAL CLASSIFICATION

Inorganic.

PHYSICAL AND CHEMICAL DATA

Water Solubility: Insoluble [1]
Vapor Pressure: Insignificant at 25°C [1]
Henry's Law Constant: Not Applicable
Specific Gravity: 5.727 at 25/5°C [2]
Organic Carbon Partition Coefficient: NA

BACKGROUND CONCENTRATIONS

Arsenic is a naturally-occurring element. The concentration of arsenic in minimally disturbed soils varies tremendously. A collection of 1,257 soil samples from across the conterminous U.S. determined that 90 percent were less than or equal to 10 ppm, with a geometric mean of 5.2 ppm, but with a maximum value as high as 100 ppm [3].

FATE AND TRANSPORT

Elemental arsenic is extremely persistent in both water and soil. Environmental fate processes may transform one arsenic compound to another; however, arsenic itself is not degraded. Soluble forms of arsenic tend to be quite mobile in water, while less soluble species adsorb to clay or soil particles. Microorganisms in soils, sediments, and water can reduce and methylate arsenic to yield methyl arsines, which volatilize and enter the atmosphere. These forms then undergo oxidation to become methyl arsonic acids and are ultimately transformed back to inorganic arsenic [1].

Bioconcentration of arsenic occurs in aquatic organisms, primarily in algae and lower invertebrates. Biomagnification in aquatic food chains does not appear to be significant, although some fish and invertebrates contain high levels of arsenic compounds which are relatively inert toxicologically. Plants may accumulate arsenic, subject to various factors including soil arsenic concentration, plant type, and soil characteristics [1].

HUMAN TOXICITY

General. Arsenic is a long-recognized human poison capable of producing a lethal reaction and cancer. The major targets of arsenic toxicity are the respiratory system, gastrointestinal system, nervous system, hematological system and skin [1]. Studies in animals suggest that low levels of arsenic may be necessary to maintain good health, but this has not been shown in humans [1]. Arsenic is considered a weak mutagen and has been placed in weight-of-evidence cancer Group A, indicating that it is a human carcinogen [4].

Oral Exposure. A chronic oral RfD of 0.0003 mg As/kg/day is based on a NOAEL of 0.0008 mg As/kg/day for hyperpigmentation, keratosis and possible vascular complications in a chronic oral study in humans [4]. Arsenic is readily absorbed following oral exposure. Acute oral LD_{50} values of 26 mg/kg for mice and 15 to 110 mg/kg for rats are reported [1]. The fatal dose in humans is estimated to be 2 mg/kg [1]. Low-level oral exposure (> 0.01 mg As/kg/day) may cause irritation of the digestive tract, pain, nausea, vomiting, diarrhea, skin abnormalities, decreased production of blood cells, abnormal heart function, blood-vessel damage, liver damage, kidney damage, and impaired nerve function ("pins and needles" sensation). In animal studies, high doses of arsenic (> 14 mg As/kg/day) have resulted in effects on the developing fetus. These effects have not been observed in humans [1]. In humans, chronic, oral exposure to low doses of arsenic (> 0.01 mg As/kg/day) has been shown to cause cancer of the skin, liver, bladder, and lung. The most characteristic effect of long-term oral exposure to arsenic is a darkening of the torso and the appearance of small "corns" or "warts" on the palms, soles, and torso. These "corns" or "warts" may develop into skin cancer [1]. An oral Unit Risk of 0.00005 $(ug\ As/L)^{-1}$ [1.75 $(mg/kg/day)^{-1}$] has recently been adopted by the USEPA [4]. The Unit Risk is based on the increased incidence of skin cancer in humans exposed to arsenic in the drinking water.

Inhalation Exposure. An inhalation RfC is not available for inorganic arsenic [4]. Approximately 40% of an inhaled concentration of arsenic is absorbed [1]. Inhalation of arsenic has not been reported to be fatal in humans, and acute inhalation LC_{50} values are not available [1]. Inhalation of arsenic at concentrations greater than 0.1 mg As/m^3 may result in irritation of the nose and throat, leading to laryngitis, bronchitis, or rhinitis [1]. Effects on the skin, nervous system, and gastrointestinal system similar to those found following oral exposure have been observed in humans following inhalation exposure. Of much greater concern, however, is that inhaled arsenic has been found to increase the risk of lung cancer in humans [1]. An inhalation Unit Risk of 0.0043 $(ug\ As/m^3)^{-1}$ was derived by USEPA [4] based on the increased incidence of lung cancer in occupationally exposed workers. Several epidemiology studies have suggested

an association between arsenic inhalation and an increased risk of developmental effects (congenital malformations, low birth weight, spontaneous abortion) [1]. Studies in animals support the view that arsenic is a developmental toxicant, but only at high doses (20 mg/m3) [1].

Dermal Exposure. Arsenic has not been reported to be fatal following dermal contact [1]. Dermal contact with arsenic may result in mild to severe irritation of the skin and mucous membranes and could lead to dermal sensitization [1].

REFERENCES

1. ATSDR, 1991. Toxicological Profile for Arsenic (Draft). Agency for Toxic Substances and Disease Registry. USPHS/USEPA. October, 1991.
2. Merck, 1989. The Merck Index. Eleventh Edition. Merck & Company, Inc. Rahway, NJ.
3. USGS, 1984. Elemental Concentrations in Soils and Other Surficial Materials of the Conterminous United States. United States Geological Survey Professional Paper 1270, U.S. Department of the Interior. United States Government Printing Office, Washington, D.C. 105 pp.
4. USEPA, 1993. Integrated Risk Information System (IRIS). On-line data base. October 5, 1993.

BARIUM

CAS NUMBER

7440-39-3

COMMON SYNONYMS

None.

ANALYTICAL CLASSIFICATION

Inorganic.

PHYSICAL AND CHEMICAL DATA

Water Solubility: decomposes [1]
Vapor Pressure: insignificant at 25°C [1]
Henry's Law Constant: Not Applicable
Specific Gravity: 3.51 at 20/20°C [1]
Organic Carbon Partition Coefficient: NA

BACKGROUND CONCENTRATIONS

Barium is a naturally-occurring element. The concentration of barium in minimally disturbed soils varies tremendously. A collection of 1,319 soil samples from across the conterminous U.S. determined that 86 percent were less than or equal to 700 ppm, with a geometric mean of 440 ppm, but with a maximum value as high as 3,000 ppm [2].

FATE AND TRANSPORT

Barium is a highly reactive metal that occurs naturally only in the combined state. Most barium released to the environment from industrial sources is in forms that do not become widely dispersed. In the atmosphere, barium is likely to be present in the particulate form. Environmental fate processes may transform one barium compound to another; however, barium itself is not degraded. It is removed from the atmosphere primarily by wet or dry deposition [1].

In aquatic media, barium is likely to precipitate out of solution as an insoluble salt, or adsorb to suspended particulate matter. Sedimentation of suspended solids removes a large portion of the barium from surface waters. Barium in sediments is found largely in the form of barium sulfate. Bioconcentration in freshwater aquatic organisms is minimal [1].

Barium in soil may either be taken up to a small extent by vegetation, or transported through soil with precipitation. Barium is not very mobile in most soil systems. The

higher the level of organic matter, the greater the adsorption. The presence of calcium carbonate will also limit mobility. Mobility is increased in the presence of high chloride concentrations. Barium complexes with fatty acids, for example, in acidic landfill leachate, will be much more mobile [1].

HUMAN TOXICITY

General. The primary target of barium toxicity is the cardiovascular system [1]. Information regarding the genotoxicity of barium are equivocal. Barium has not been placed in a weight-of-evidence cancer group by the USEPA [3].

Oral Exposure. A chronic oral RfD of 0.07 mg/kg/day is based on a NOAEL of 0.21 mg/kg/day for increased blood pressure in a long-term drinking water study in humans [3]. Barium is poorly absorbed following oral exposure (about 5%) [1]. In rats, acute oral LD_{50} values range from 132 to 277 mg/kg [1]. In humans, ingestion of very large amounts of barium (doses not reported) over a short period may cause paralysis or death. Ingestion of lower doses of barium over a short period may result in difficulties in breathing, increased blood pressure, changes in heart rhythm, stomach irritation, minor changes in blood, muscle weakness, changes in nerve reflexes, swelling of the brain, and damage to the liver, kidney, heart, and spleen [1]. Studies in animals report effects similar to those found in humans. Barium sulfate is sometimes given orally or rectally for the purpose of making X-rays. This has not been shown to be harmful [1]. There is no evidence that oral exposure to barium affects human reproduction or development and developmental and reproduction studies in animals are inconclusive [1]. Barium has not been shown to cause cancer in humans or animals following oral exposure, therefore, an oral slope factor is not available [1,3].

Inhalation Exposure. A chronic inhalation RfC for barium is not available [3]. Approximately 65% of an inhaled concentration of barium is absorbed following inhalation exposure [1]. Barium has not been reported to be fatal to humans or animals following inhalation exposure [1]. Studies examining the toxicity of inhaled barium in humans and animals are extremely limited but suggest that exposure results in effects on the respiratory, cardiovascular, and gastrointestinal systems [1]. There is no evidence that inhaled barium affects human reproduction or development, but studies in animals suggest that barium may have adverse effects on these processes [1]. Barium is not known to cause cancer in humans or animals following inhalation exposure, therefore, an inhalation unit risk is not available [1,3].

Dermal Exposure. Dermal exposure to barium has not been reported to be fatal in humans or animals. Limited animal studies indicate that barium is a dermal and ocular irritant, but the results of this study are inconclusive [1].

ECOLOGICAL TOXICITY

General. Barium compounds are generally insoluble making them relatively unavailable for biological uptake [4]. All water- or acid-soluble barium compounds are poisonous. Barium is considered a nonessential element for plants and animals.

Vegetation. There are very few reports of barium toxicity to plants, except under conditions of acidic soils or with highly concentrated soil solutions where the bioavailable fractions are excessive (e.g., 2 mg/L soluble barium). Some authors report that concentrations of barium need to be extreme before toxicity occurs. Barium accumulation in plants is unusual except when the barium concentration exceeds calcium and magnesium concentrations in the soil, a condition which may occur when sulfate is depleted [5].

Aquatic Life. Barium ions in general are rapidly precipitated or removed from solution by chemical bonding, adsorption, and sedimentation. In most natural water, there is sufficient sulfate or carbonate to precipitate soluble barium present in the water, converting it to an insoluble nontoxic compound [5]. Experimental data indicate that soluble barium concentrations would have to exceed 50,000 g/L before toxic effects to aquatic life might be observed [4]. Other data show the concentrations of barium lethal to half the test population of fish range from 150 to 10,000 mg/L [6]. Because barium represents little hazard under natural conditions, there are no federal aquatic life water quality standards [7].

Wildlife. Soluble barium compounds such as barium chloride, barium carbonate, barium sulfide, and barium oxide are highly toxic to animals when injested [8], although it is unlikely that suitable conditions would exist under natural conditions to accommodate exposure to these compounds. No reports of barium toxicity to wildlife under natural conditions were identified.

REFERENCES

1. ATSDR, 1990. Toxicological Profile for Barium. Draft. Agency for Toxic Substances and Disease Registry. USPHS/USEPA. October 1990.

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3. USEPA, 1992. Integrated Risk Information System (IRIS). Data base. Online. August 3, 1992.

4. CH2M Hill, Inc., 1989. Preliminary Endangerment Assessment for Lowry Landfill. Denver, Colorado.

5. U.S. Environmental Protection Agency. 1983. Hazardous Waste Land Treatment (revised edition). Office of Solid Waste and Emergency Response. SW-874. Washington, D.C.

6. Snyder, Bruce D. and Janet L. Snyder. 1984. Feasibility of Using Oil Shale Wastewater for Waterfowl Wetlands. U.S. Fish and Wildlife Service. FWS/OBS-84/01.

7. U.S. Environmental Protection Agency. 1991. Water Quality Criteria Summary. Washington, D.C.

8. U.S. Fish and Wildlife Service. 1978. Impacts of Coal-Fired Power Plants on Fish, Wildlife, and their Habitats. FWS/OBS-78/29.

CADMIUM

CAS NUMBER

7440-43-9

COMMON SYNONYMS

None noted.

ANALYTICAL CLASSIFICATION

Inorganic.

PHYSICAL AND CHEMICAL DATA

Water Solubility: Insoluble [1]
Vapor Pressure: Negligible [2]
Henry's Law Constant: ND
Specific Gravity: 8.65 at 25/4°C [1]
Organic Carbon Partition Coefficient: ND

BACKGROUND CONCENTRATIONS

Pure cadmium is a silver-white, blue-tinged, lustrous metal with a distorted hexagonal close-packed structure; cadmium is easily cut with a knife. Cadmium can be found in zinc ores, as greenockite (CdS), and as otavite ($CdCO_3$). The estimated occurrence of cadmium in the earth's crust is from 0.1 to 0.2 ppm [1]. No data on cadmium were gathered as part of the 1984 Department of the Interior survey of conterminous United States soils [3].

FATE AND TRANSPORT

Elemental cadmium is insoluble in water [1], while cadmium compounds show varying degrees of solubility depending on the nature of the compounds and the aquatic environment [2]. Cadmium in the environment may be found as cadmium salts, hydrated cations, or organic/inorganic cadmium complexes. As hydrated cations or complexes, cadmium may be considered fairly mobile in water (relative to other heavy metals). Cadmium in soils may leach into water, especially under acidic conditions. It does not volatilize from either waters or soils, but does exhibit a tendency to adsorb strongly to clays, muds, and humic/organic materials in soils and waters. Complexation and sorbing with organic materials are the most important factors in aquatic fate and transport. The evidence indicates that cadmium bioconcentrates in all levels of the food chain. Cadmium accumulation has been reported in many animal and plant

species. Reported BCFs range from 113 to 18,000 for invertebrates, and from 3 to 2,213 for fish. The pH and humus content of the water affect bioconcentration [2].

HUMAN TOXICITY

General. Breathing air with very high levels of cadmium severely damages the lungs and can cause death. High cadmium levels in the diet severely irritate the digestive tract, while lower levels consumed over a long period of time may cause kidney damage [2]. The USEPA has placed cadmium in weight-of-evidence Group B1, indicating that it is a probable human carcinogen [4].

Oral Exposure. A chronic oral RfD of 0.0005 mg/kg/day for water is based on a NOAEL of 0.005 mg/kg/day for proteinuria following chronic exposures in humans. A chronic oral RfD of 0.001 mg/kg/day for food is based on a NOAEL of 0.01 mg/kg/day for proteinuria following chronic exposures in humans [4]. It is estimated that humans absorb about 5 percent of ingested cadmium [2]. In rats and mice the acute oral LD_{50} values range from about 100 to 300 mg/kg. Two human deaths due to intentional ingestion of cadmium resulted from doses of 25 and 1,500 mg/kg [4]. Symptoms of acute toxic reaction to ingestion may include gastroenteritis, vomiting, diarrhea, abdominal pain, increased salivation, choking, anemia, hypotension, respiratory arrest, pulmonary edema, renal dysfunction, and death. Chronic oral overexposure symptoms may include renal dysfunction and/or failure, as well as anemia [1,2,5]. Cadmium has been implicated as a fetotoxin by the oral route in animal studies [2].

Inhalation Exposure. The USEPA does not currently provide an inhalation RfC for cadmium [4,6], although it is pending. It is estimated that humans rapidly absorb about 25 percent of inhaled cadmium. The 15-minute LC_{50} for rats exposed to cadmium oxide fumes is approximately 33 mg/m^3. It has been estimated that exposure to 1 mg/m^3 for 8 hours might be sufficient to cause death in humans [2]. Symptoms associated with acute cadmium poisoning via inhalation may include fever, headache, dyspnea, pleuritic chest pain, conjunctivitis, rhinitis, sore throat, cough, pulmonary edema, extreme restlessness, respiratory failure, and death. Chronic inhalation overexposure symptoms may include renal dysfunction and/or failure, dyspnea, emphysema, bronchitis, and anemia [1,2,5]. Cadmium has been implicated as a developmental toxin by the inhalation route in animal studies [2]. An inhalation unit risk of 0.0018 $\mu g/m^3$ is based on excess lung cancers observed in humans [4].

Dermal Exposure. Cadmium is poorly absorbed through the skin [2]. No other useful information regarding dermal exposure to cadmium was located.

REFERENCES

1. Merck, 1989. The Merck Index. Eleventh Edition. Merck & Company, Inc. Rahway, NJ.
2. ATSDR, 1991. Toxicological Profile for Cadmium. Agency for Toxic Substances and Disease Registry. USPHS/USEPA. October 1991.
3. USGS, 1984. Elemental Concentrations in Soils and Other Surficial Materials of the Conterminous United States. United States Geological Survey Professional Paper 1270, U.S. Department of the Interior. United States Government Printing Office, Washington, D.C. 105 pp.
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6. USEPA, 1993. Health Effects Assessment Summary Tables (HEAST). Office of Emergency and Remedial Response. OHEA ECAO-CIN-821. March 1993.

CHROMIUM

CAS NUMBER

7440-47-3

COMMON SYNONYMS

None.

ANALYTICAL CLASSIFICATION

Inorganic.

PHYSICAL AND CHEMICAL DATA

Water Solubility: Insoluble [1]
Vapor Pressure: Insignificant at 25°C [1]
Henry's Law Constant: Not Applicable
Specific Gravity: 7.2 at 28°C [2]
Organic Carbon Partition Coefficient: NA

BACKGROUND CONCENTRATIONS

Chromium is a naturally-occurring element which is dispersed throughout the environment primarily as a result of anthropogenic activities [1]. The concentration of chromium in minimally disturbed soils varies tremendously. A collection of 1,319 soil samples from across the conterminous U.S. determined that 87 percent were less than or equal to 70 ppm, with a geometric mean of 37 ppm, but with a maximum value as high as 700 ppm [3].

FATE AND TRANSPORT

Two of the major forms of chromium are trivalent chromium (chromium III) and hexavalent chromium (chromium VI). Chromium is released into the atmosphere mainly by the combustion of coal and oil. The most toxic form is hexavalent chromium, which is due mainly to chemical manufacture, primary metal production, chrome plating, and cooling towers. Chromium is removed from the atmosphere by fallout and precipitation, but may be transported long distances before removal. The residence time of atmospheric chromium is expected to be less than 10 days. There are no known chromium compounds that can volatilize from water. Most of the trivalent form is expected to precipitate in sediments. Hexavalent chromium will be present predominantly in the soluble form. Hexavalent chromium will eventually be reduced to the trivalent form by the organic materials present in surface water. The residence time

of chromium in lake water is estimated to be in the range of 4.6 to 18 years. Bioconcentration should be minimal [1].

Chromium in soil may become airborne due to fugitive dust emissions, while runoff and leaching may transport it to surface water and groundwater. Flooding of soils and the subsequent anaerobic decomposition of plant material may increase the mobilization of chromium from soils. The half-life of chromium in soils may be several years [1].

HUMAN TOXICITY

General. There are two forms of chromium that are of concern: chromium III and chromium VI. In general, chromium (VI) compounds are more toxic than chromium (III) compounds [1]. Trivalent chromium (chromium III) is considered an essential nutrient which helps to maintain normal glucose, cholesterol, and fat metabolism. A daily ingestion of 0.05 to 0.20 mg/day (0.0007 to 0.003 mg/kg/day) is estimated to be safe and adequate [1]. The major targets of chromium toxicity are the respiratory system and the gastrointestinal system. Chromium is considered to be genotoxic. The USEPA [4] has placed chromium (VI) in weight-of-evidence cancer Group A, indicating that it is a human carcinogen; for oral exposure, chromium (VI) has been placed in weight-of-evidence Group D, indicating that it is not classifiable as to human carcinogenicity via oral exposure. Chromium (III) has not been placed in a cancer class by the USEPA [4].

Oral Exposure. A chronic oral RfD value of 1 mg Cr/kg/day for chromium (III) is based on a NOEL of 1,468 mg Cr/kg/day for adverse effects in a chronic feeding study in rats [4]. An oral RfD of 0.005 mg Cr/kg/day for chromium (VI) is based on a NOAEL of 2.4 mg Cr/kg/day for adverse effects in a 1-year drinking study in rats [4]. Chromium is poorly absorbed following oral exposure. Acute oral LD_{50} values in rats ranged from 13 to 2,365 mg Cr/kg, depending on the chromium compound [1]. Short-term oral exposure of humans to high doses of chromium (> 4.1 mg Cr (VI)/kg/day) has resulted in stomach upsets and ulcers, convulsions, liver and kidney damage, and even death [1]. Information regarding potential effects of chromium on human reproduction and development is not available. Exposure of animals to chromium (VI) (57 mg Cr (IV)/kg/day) during pregnancy has been found to result in developmental effects on the fetus [1]. Treatment of male mice with chromium (III) and (VI) (> 3.5 mg Cr/kg/day) has caused effects on spermatogenesis [1]. Evidence that oral exposure to chromium (III) or (VI) causes cancer in humans or animals is under review, therefore an oral slope factor is not available [4].

Inhalation Exposure. Inhalation RfC values for both chromium (III) and chromium (VI) are currently under review by the USEPA [4]. Following inhalation exposure,

approximately 53-85% of chromium (VI) compounds and 5-30% of chromium (III) compounds are absorbed into the blood [1]. Acute (4-hour) inhalation LC_{50} values in rats ranged from 29 to 137 mg/kg, depending on the chromium compound [1]. In humans, acute inhalation of chromium has not been reported to be fatal. The respiratory system is the major target of toxicity for both forms of chromium following inhalation exposure. Respiratory effects include perforations and ulcerations of the nasal septum, bronchitis, pneumonoconiosis (inflammation of the lung leading to fibrosis), decreased pulmonary function, pneumonia, rhinorrhea (runny nose), nasal itching and soreness, and epistaxis (nose bleed) [1]. These effects have occurred at concentrations > 0.002 mg Cr (VI)/m^3. In some chromium-sensitive people, chromium exposure may trigger an allergic response manifested by asthma or a skin rash. There is no conclusive evidence that inhaled chromium causes reproductive or developmental effects in humans or animals [1]. Long-term inhalation exposure of workers to low levels of chromium compounds (> 0.04 mg Cr/m^3) has been associated with lung cancer. The form of chromium responsible for this effect has not been established, but only hexavalent chromium has been found to cause cancer in animal studies. An inhalation Unit Risk of 0.012 $(ug/m^3)^{-1}$ for chromium (VI) is based on an increase in the incidence of lung cancer in occupationally exposed workers [4]. An inhalation Unit Risk is not available for chromium (III) [4].

Dermal Exposure. Acute dermal LD_{50} values in rabbits ranged from 30 to 553 mg Cr/kg depending on the chromium compound [1]. Dermal exposure to chromium has been found to be fatal in humans, but the exact exposure dose is not known [1]. Dermal exposure of humans to chromium can cause allergic reactions as well as skin burns, blisters, and ulcers [1]. Exposure of animals to chromium results in effects similar to those found in humans.

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4. USEPA, 1993. Integrated Risk Information System (IRIS). On-line data base. October 5, 1993.

COPPER

CAS NUMBER

7440-50-8

COMMON SYNONYMS

None.

ANALYTICAL CLASSIFICATION

Inorganic.

PHYSICAL AND CHEMICAL DATA

Water Solubility: Insoluble [1]
Vapor Pressure: Insignificant at 25°C [1]
Henry's Law Constant: Not Applicable
Specific Gravity: 8.94 [2]
Organic Carbon Partition Coefficient: NA

BACKGROUND CONCENTRATIONS

Copper is a naturally-occurring element. The concentration of copper in minimally disturbed soils varies tremendously. A collection of 1,311 soil samples from across the conterminous U.S. determined that 85 percent were less than or equal to 30 ppm, with a geometric mean of 17 ppm, but with a maximum value as high as 700 ppm [3].

FATE AND TRANSPORT

Copper is dispersed throughout the atmosphere primarily as a result of anthropogenic activities. Environmental fate processes may transform one copper compound to another; however, copper itself is not degraded. Most of the copper in the atmosphere occurs in the aerosol form, and long-distance transport may occur. Wet or dry deposition is expected to be the primary fate process in air.

Several processes determine the fate of copper in aquatic environments: formation of complexes, especially with humic substances; sorption to hydrous metal oxides, clays, and organic materials; and bioaccumulation. Organic complexes of copper are more easily adsorbed on clay and other surfaces than the free form. The aquatic fate of copper is highly dependent on factors such as pH, oxidation-reduction potential, concentration of organic matter, and the presence of other metals. In regard to the latter, it has been demonstrated that coprecipitation of copper with hydrous oxides of

iron effectively scavenges copper from solution, although in most surface waters, organic materials prevail over inorganic ions in complexing copper [4].

Generally, copper is considered to be among the more mobile of the heavy metals in surface environments. Seasonal fluctuations have been observed in surface water copper concentrations, with higher levels in fall and winter, and lower levels in the spring and summer. It is not expected to volatilize from water. Since copper is an essential nutrient, it is strongly accumulated by all plants and animals, but is probably not biomagnified [4].

The degree of persistence of copper in soil depends on the soil characteristics and the forms of copper present. For example, in soils of low organic content, soluble copper compounds may move into groundwater at a significant rate. On the other hand, the presence of organic complexing agents may restrict movement in soil, and copper may be immobilized in the form of various inorganic complexes. It is not expected to volatilize from soil.

HUMAN TOXICITY

General. Copper is an essential trace element; therefore, toxic effects can result if too much or too little is taken into the body. The Recommended Dietary Allowance (RDA) for copper is 2 to 3 mg/day (0.03 to 0.04 mg/kg/day) [5]. The major targets of copper toxicity are the gastrointestinal tract following oral exposure and the lungs following inhalation exposure [5]. Information regarding the genotoxicity of copper are equivocal. USEPA has placed copper in weight-of-evidence Group D, indicating that it is not classifiable as to human carcinogenicity [6].

Oral Exposure. A chronic oral RfD of 1.3 mg/L (0.04 mg/kg/day) is based on a LOAEL of 5.3 mg/L for gastrointestinal irritation in humans [7]. Approximately 60% of an oral dose of copper is absorbed through the gastrointestinal tract [5]. Case studies of human suicides indicate that doses of 6 to 637 mg/kg have been fatal [5]. LD_{50} values are not available for animals. In humans, doses greater than 0.07 mg/kg have resulted in gastrointestinal effects including vomiting, diarrhea, nausea, abdominal pain, and a metallic taste in the mouth [5]. Adverse effects were also noted in the liver (necrosis) and the kidneys (necrosis, tubular damage) of humans following oral exposure [5]. Chronic toxic effects due to copper are rarely seen except for individuals with Wilson's Disease. Wilson's Disease is a genetically determined condition in which the body absorbs and retains abnormally high copper concentrations [5]. It is not known whether exposure to copper will result in effects on reproduction or development in humans, but animal studies indicate that copper exposure may increase

fetal mortality [5]. There is no evidence that copper causes cancer in humans or animals, therefore, an oral slope factor for cancer is not available [6].

Inhalation Exposure. A chronic inhalation RfC is not available for copper [6]. The extent of copper absorption following inhalation exposure is not known. Information regarding the fatal dose of copper following inhalation exposure was not located for humans or animals. In humans, copper is a respiratory irritant. Short-term inhalation exposure to copper dust or fumes (0.075-0.12 mg/m^3) results in a condition known as "metal fume fever." This condition is a 24-48 hour illness characterized by chills, fever, aching muscles, dryness in the mouth and throat, and headache [5]. Respiratory effects have also been noted in animals [5]. Information is not available regarding potential effects on reproduction and development in humans or animals following inhalation exposure. There is no evidence that copper exposure causes cancer in human or animals, therefore, an inhalation unit risk for cancer is not available [6].

Dermal Exposure. Dermal exposure to copper may result in allergic contact dermatitis [5]. Other information regarding the toxic effects of dermal exposure to copper are not available [5].

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CYANIDE

CAS NUMBER

57-12-5

COMMON SYNONYMS

None noted.

ANALYTICAL CLASSIFICATION

Inorganic (wet chemistry).

PHYSICAL AND CHEMICAL DATA

Note: Data is for hydrogen cyanide (HCN).

Water Solubility: miscible [1]
Vapor Pressure: 264.3 mm Hg at)°C [1]
Henry's Law Constant: 5.1 x 10^{-2} atm-m^3/mole [1]
Specific Gravity: 0.6884 at 20°C (liquid) [1]
Organic Carbon Partition Coefficient: ND

FATE DATA: HALF-LIVES

Soil: ND
Air: ND
Surface Water: ND
Groundwater: ND

NATURAL SOURCES

Fruits, roots, and leaves of numerous plants [1].

ARTIFICIAL SOURCES

Vermicidal fumigants; insecticides; rodenticides; metal polishes; electroplating solutions; metallurgical processes [1,2].

FATE AND TRANSPORT

Cyanides may be found in the environment bound with organic and/or inorganic cations. The fate and transport of cyanide, therefore, is dependent upon the properties of the cyanide-bound material. Any discussion attempting to encompass all properties of cyanide-bound materials is beyond the scope of this assessment.

Cyanides may occur in soils as hydrogen cyanide, alkali metal salts, or immobile metallocyanide complexes. The fate of cyanides in soil will be largely dependent upon pH conditions of that soil. Volatilization of hydrogen cyanide from surface soils is expected to be a primary removal mechanism for soils having a pH of 9.2 or less. Though cyanide typically does not sorb strongly to soils (or organic matter therein), leaching to unprotected groundwaters is not expected to be significant due to the probability of cyanide fixation by trace metals found in soils, or transformation of cyanide via microbial action. However, if the initial cyanide loading proves toxic to soil-based microorganisms, leaching to groundwater may be expected. In water, cyanide occurs most commonly in the form of hydrogen cyanide. Hydrogen cyanide is removed from water primarily by volatilization. The rate of volatilization is also pH-dependent, with more rapid volatilization occurring at lower pH values [1].

Although simple metal cyanides and hydrogen cyanide are not expected to bioconcentrate in aquatic organisms, concentrations of simple metal cyanides have been detected in the tissues of fish exposed to waters containing silver and copper metal complexes. There is, as well, no evidence of biomagnification through trophic levels. Adsorption to suspended solids and sediments in waters will occur, but is expected to be a minor pathway in comparison to volatilization and biodegradation. [1]

Atmospheric concentrations of cyanide will exist almost exclusively as hydrogen cyanide, though small amounts of metal cyanides may exist associated with particulate matter. Given the relatively slow degradation rate of hydrogen cyanide in the atmosphere, this material has the potential to be transported for long distances. The most important removal mechanism for hydrogen cyanide in the atmosphere is via reaction with photochemically-produced hydroxyl radicals. Removal of hydrogen cyanide via either dry or wet deposition is expected to be a negligible mechanism. Metal cyanides (as particulates) will, however, be subject to deposition via gravitational settling and/or rainfall washout. [1]

HUMAN TOXICITY

General. Cyanide is highly toxic to humans following all routes of exposure. Cyanide acts by inhibiting enzymes that are needed to use oxygen efficiently, resulting in respiratory arrest. The major targets of cyanide toxicity are the central nervous system, the lungs and the heart [1]. Cyanide is not mutagenic and has been placed in weight-of-evidence cancer Group D, indicating that it is not classifiable as to human carcinogenicity [3].

Oral Exposure. A chronic oral RfD of 0.02 mg/kg/day is based on the NOAEL of 10.8 mg/kg/day for weight loss, thyroid effects and nervous system effects in a chronic study in rats [3]. Cyanide is readily absorbed following oral exposure. Acute oral LD_{50} values ranged from 2.7 to 11 mg/kg in rats, 2.34 to 2.70 mg/kg in rabbits and 4.3 mg/kg in mice [1,2]. In humans, an average fatal dose of 1.52 mg/kg has been calculated based on case reports of intentional or accidental poisonings. The lowest reported fatal dose in humans was 0.56 mg/kg [1]. Acute oral poisoning results in effects on the gastrointestinal system (vomiting), the heart (atrial fibrillation, shallow pulse, inaudible heart sounds), kidneys (increased protein output) and nervous system (tremors, stupor, coma). These effects have occurred at doses above 15 mg/kg [1]. Similar effects have been found in animals. Information regarding potential effects of cyanide on reproduction and development in humans are not available, but studies in animals indicate that effects on development may result following oral exposure [1]. Cyanide is not known to cause cancer in humans or animals following any route of exposure, therefore, an oral slope factor is not available [3].

Inhalation Exposure. A chronic inhalation RfC is not available for cyanide [3]. Cyanide is readily absorbed following inhalation exposure. Acute inhalation LC_{50} values vary according to duration of exposure: in rats, values ranged from 3,417 ppm (10 seconds) to 142 ppm (60 minutes), and in rabbits, values ranged from 2,200 ppm (45 seconds) to 208 ppm (35 minutes) [1]. In humans, an average fatal concentration is estimated to be 546 ppm for a 10-minute exposure. Exposure to 110 to 135 ppm for greater than an hour can be life-threatening, while exposure to 18-36 ppm for the same time period may not cause any effects [1]. Acute exposures to approximately 6 ppm and above may result in effects on the respiratory system (dyspnea, nasal irritation), cardiovascular system (chest pain, heart palpitations), gastrointestinal system (abdominal pain, nausea, vomiting), and nervous system (lightheadedness, breathlessness, numbness, headaches, and, at higher concentrations, coma). Chronic inhalation exposure of workers to comparable concentrations results in effects similar to those reported following acute exposure. Information regarding the potential effects of cyanide on reproduction and development are not available in humans or animals [1]. Cyanide is not known to cause cancer in humans or animals following any route of exposure, therefore, an inhalation unit risk is not available [3].

Dermal Exposure. The average fatal dose of cyanide in humans following dermal exposure was estimated to be 100 mg/kg [1]. Acute dermal LD_{50} values in rabbits

ranged from 1.0 to 8.93 mg/kg [1]. Toxic effects observed following dermal exposure are similar to those following other routes of exposure [1].

ECOLOGICAL TOXICITY

General. Cyanide is a highly lethal, but short-lived noncumulative poison. No evidence was found of either cyanide bioaccumulation or biomagnification (Snyder and Snyder, 1984). Hydrogen cyanide is the most common and the most toxic of the cyanides. The environmental chemistry of cyanide is complex, with cyanide gas (HCN) and ionic cyanide (CN^-) representing the toxic chemical forms.

Vegetation. Cyanide seldom remains biologically available in soils because it is either complexed by trace metals, metabolized by various microorganisms, or lost through volatilization. In plants, elevated cyanide concentrations inhibit respiration (Eisler, 1991). Some plant species, such as arrowgrass (*Triglochin* sp.) wind wild cherry (*Prunus*), are natural producers of cyanocompounds and will have inherent high concentrations of these compounds in their tissues.

Aquatic. Cyanide in aquatic systems exists as simple hydrocyanic acid; as water-soluble alkali metal salts, such as potassium cyanide and sodium cyanide; and as metallocyanide complexes of variable stability (Snyder and Snyder, 1984). Cyanide toxicity increases with decreasing pH and dissolved oxygen. Cyanide concentrations in the range from 50 to 100 μg/L have proven to eventually fatal to many sensitive fishes and levels above 200 μg/L probably are rapidly fatal to most fish species (USEPA, 1976).

The 96-hour LC_{50} of cyanide for bluegill was 56.0 to 227.0 μg/L and the maximum toxicant concentration was 9.3 to 19.8 μg/L (Eisler, 1991). The 96-hour LC_{50} of cyanide for juvenile and adult fathead minnows was 117.0 to 157.0 μg/L and 121.0 to 129.0 μg/L, respectively (Engineering-Science, Inc., 1991). During chronic exposure, cyanide inhibited spawning in bluegill at 5.0 μg/L and reduced growth rate in fathead minnows at 35.0 μg/L (Eisler, 1991). The federal chronic freshwater quality criterion for cyanide is 5.2 μg/L (USEPA, 1991). The Ohio aquatic life habitat and water supply standard for cyanide is 12.0 μg/L for warmwater and modified warmwater habitats (OEPA, 1991).

Wildlife. Cyanide is acutely toxic to birds and mammals in very small concentrations. Cyanide biomagnification in the food chain has not been reported, possibly due to rapid detoxification of sublethal doses by most species, and death at higher doses (Eisler, 1991). In mallards, a single oral dose of cyanide of 0.53 mg/kg body weight produced no deaths, but an LC_{50} result was produced at 1.43 mg/kg

body weight (Eisler, 1991). In rabbits, a single oral dose of 10.0 to 15.0 mg/kg body wight produced a 100 percent kill in 14 to 30 minutes (Eisler, 1991).

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LEAD

CAS NUMBER

7439-92-1

COMMON SYNONYMS

None.

ANALYTICAL CLASSIFICATION

Inorganic.

PHYSICAL AND CHEMICAL DATA

Water Solubility: Insoluble [1]
Vapor Pressure: insignificant at 25°C [1]
Henry's Law Constant: Not applicable [1]
Specific Gravity: 11.34 at 20/4°C [2]
Organic Carbon Partition Coefficient: ND [1]

FATE DATA: HALF-LIVES

Note: Data for tetraethyl lead; CAS No. 78-00-2

Soil: 1 to 4 weeks [3]
Air: 2.3 to 9.0 hours [3]
Surface Water: 2.3 to 9.0 hours [3]
Groundwater: 2 to 8 weeks [3]

BACKGROUND CONCENTRATIONS

Lead is a naturally-occurring element which is dispersed throughout the environment primarily as a result of anthropogenic activities [1]. The concentration of lead in minimally disturbed soils varies tremendously. A collection of 1,300 soil samples from across the conterminous U.S. determined that 80 percent were less than or equal to 30 ppm, with a geometric mean of 16 ppm, but with a maximum value as high as 700 ppm [4]. Concentrations along roadways and adjacent to houses with exterior lead-based paints may be as high as 10,000 ppm [1].

FATE AND TRANSPORT

Lead is extremely persistent in both water and soil. Environmental fate processes may transform one lead compound to another; however, lead itself is not degraded. It is largely associated with suspended solids and sediments in aquatic systems, and it occurs

in relatively immobile forms in soil. Lead which has been released to soils may become airborne as a result of fugitive dust generation. Tetraethyl lead may occur in the vapor phase [1].

HUMAN TOXICITY

General. The general human population is exposed to lead primarily via the oral route of exposure, with some contribution from the inhalation route. However, in some subpopulations, the predominant route of exposure is via inhalation. The effects of lead are the same regardless of whether it enters the body through breathing or ingestion. The major health threat from lead arises from the damage it causes to the brain, especially in fetuses, infants, and young children. Young and developing humans are highly sensitive to its effects. Also, young children are prone to ingest more lead as a result of normal mouthing behavior. Decreased IQ and reduced growth may result from childhood exposure. Fetal exposure may result in preterm birth, reduced birth weight, and decreased IQ [1]. The Federal Centers for Disease Control recently lowered the threshold at which children are considered to have lead poisoning from 25 to 10 micrograms of lead per deciliter of blood [6]. Some of the health effects of lead, particularly changes in the levels of certain blood enzymes and in aspects of children's neurobehavioral development, may occur at blood levels so low as to be essentially without a threshold [7].

Lead exposure may increase blood pressure in middle-aged men. High-level exposure can severely damage the brain and kidneys in adults or children. In addition, high doses of lead will cause abortion and damage the male reproductive system [1]. The USEPA currently does not provide any toxicity values for lead [7,8]. The USEPA has placed lead in weight-of-evidence Group B2, indicating that it is a probable human carcinogen [7].

Oral Exposure. Oral absorption of lead appears to be low in humans. The absorption of lead into the body is highly dependent on its state of complexation. In general, soluble lead compounds tend to be more readily absorbed into the body than insoluble compounds, and are therefore more toxic. Certain organic lead compounds are also readily absorbed. Gastrointestinal absorption is highly dependent on the form of lead and the amount of food present. For example, in one experiment 3 percent of lead chloride was absorbed when provided with a meal, but 60 percent was absorbed when animals were fasted. Lead absorption is higher in children than in adults. Oral LD_{50} values were not available. LD_{LO} values for various inorganic lead compounds reportedly ranged from 191 mg lead/kg in the dog to 20,500 mg lead/kg in the guinea pig. An LD_{LO} is the lowest dose causing death. The reported adverse effects of lead in laboratory animals following oral exposure include severe central nervous system damage,

elevated blood pressure, impaired heme synthesis, liver damage, kidney damage, fetotoxicity, and damage to the reproductive organs in both males and females. Renal tumors have been observed in laboratory animals following oral administration of lead acetate [1].

Inhalation Exposure. Once deposited in the lower respiratory tract, lead is almost completely absorbed, and all chemical forms of lead also appear to be absorbed. Limited experimental evidence suggests that inhaled tetraethyl lead is rapidly absorbed by rats [1]. No other useful information was located regarding specific adverse health effects resulting from inhalation exposure to lead.

Dermal Exposure. Compounds such as lead acetate are poorly absorbed through skin, while tetraethyl lead appears to be rapidly absorbed [1]. No other useful information was located regarding specific adverse health effects resulting from dermal exposure to lead.

ECOLOGICAL TOXICITY

General. Lead is generally considered a highly toxic contaminant because it is not an essential nutrient to either plants or animals. Lead can be bioaccummulated, but it does not biomagnify in aquatic or terrestrial food chains. The tendency for lead to form complexes with naturally occurring organic material (e.g., humic and fulvic acids) increases its adsorption affinity for clays and other mineral surfaces, and decreases its bioavailability, except under acidic soil or water conditions. Benthic microbes can methylate lead to form tetramethyl lead, which is volatile and more toxic than inorganic lead [9].

Vegetation. Lead toxicity in plants under natural conditions is uncommon even though field and laboratory studies have demonstrated lead's toxicity. Most of the lead in soils is insoluble and largely unavailable for plant uptake. Symptoms of lead toxicity are found only in plants grown on acid soils [10]. The amount of bioavailable lead taken up by plants decreases as soil pH, cation exchange capacity, and available phosphorus increase. Lead inhibits plant growth and reduces photosynthesis, mitosis, and water absorption. When taken up by plants, lead is rarely translocated because it becomes chelated in the roots [10]. Lead levels of approximately 500 mg/kg in soil reduced pollen germination by greater than 90 percent in two weed species. Normal germination rates were observed at soil levels of 46 mg/kg, but other adverse effects were observed at lead levels of 12 to 312 mg/kg [9].

Aquatic Life. The toxicity of lead in water is dependent on pH, organic materials, water hardness, and the presence of other metals [11]. Organolead compounds are more toxic than inorganic lead compounds to aquatic organisms [12]. Lead toxicity decreases with

increasing water hardness [9]. Lead is more mobile in acidic waters than in higher pH waters. In alkaline and circumneutral waters, removal of lead by sorption and precipitation may occur relatively quickly [11]. The solubility of lead ranges from 500 g/L in soft water to 3 g/L in hard water [12]. In aquatic systems, most lead is found in bottom sediments. The toxicity of lead to fish varies from 0.1 to 542 mg/L. Generally, the medium tolerance limit for fathead minnows in hard water (360 mg/L $CaCO_3$) is 482 mg/L [13]. The federal chronic freshwater quality criterion for lead is 18.6 g/L based on a water hardness of 400 mg/L $CaCO_3$ [14].

Wildlife. Lead bioaccumulates in animal tissues, but does not biomagnify in the food chain [11]. Evidence of lead poisoning in mammals and other wildlife have been reported from sites heavily contaminated by lead smelter emissions and other types of atmospheric fallout. Neurological effects in mallard ducks were observed within 24 hours of dosing them with lead shot for a total intake of 423.8 mg/kg body weight. Assuming a mallard weighs approximately 1.2 kg and consumes food equivalent to 10 percent of its body weight each day, dosage of 423.8 mg/kg body weight is equivalent to an approximate lead concentration in the food of 4,600 mg/kg [9]. It was found that 1,000 ppm dietary lead reduced egg production and caused soft-shelled eggs and 500 ppm inhibited growth and produced anemia [9].

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MERCURY

CAS NUMBER

7439-97-6

COMMON SYNONYMS

Hydragyrum; quicksilver

ANALYTICAL CLASSIFICATION

Inorganic.

PHYSICAL AND CHEMICAL DATA

Water Solubility: 0.56 mg/L [1]
Vapor Pressure: 2 x 10^{-3} mm Hg at 25°C [2]
Henry's Law Constant: ND
Specific Gravity: 13.534 at 25/4°C [2]
Organic Carbon Partition Coefficient: ND

BACKGROUND CONCENTRATIONS

Mercury is a naturally-occurring element. Elemental mercury is a silver-white, heavy, mobile, liquid metal exhibiting slight volatility at room temperature [2]. Concentrations of mercury at sampling points across the contiguous United States exhibit a limited, but varied range. A total of 1,267 soils samples were gathered by the United States Geological Survey for mercury concentration analysis [3]. Of this total, 1,263 samples exhibited some concentration of mercury across a range of <0.01 ppm to a maximum of 4.6 ppm. Fourteen percent of the total samples showed a mercury concentration of from less than 0.002 ppm up to 0.01 ppm; 16 percent showed concentrations between 0.002 ppm and 0.032 ppm, 33 percent between 0.032 and 0.051, 24 percent between 0.051 and 0.13, and 13 percent showed concentrations of mercury from 0.13 ppm up to a maximum value of 4.6 ppm; the geometric mean concentration of mercury was 0.058 ppm.

FATE AND TRANSPORT

Mercury may exist as one of three forms: elemental mercury, inorganic mercury, and organic mercury. Elemental mercury will combine with sulfur at ordinary temperatures, and react with nitric acid and/or ammonia solutions in air (to form Hg_2NOH); it does not react with hydrochloric acid, sulfuric acid (when cold), or alkalies. Mercurous salt will be slowly degraded by sunlight [2]. Inorganic mercury compounds generally

dissociate into the mercuric form (Hg^{2+}) rather than the mercurous form (Hg^{+}). Organic mercury compounds are generally divided into two broad classes: alkyl mercury (e.g., monomethyl mercury) and phenyl mercury (e.g., phenylmercury acetate). Organic mercury compounds are more easily absorbed than elemental and/or inorganic forms, but will readily undergo biodegradation with the ultimate release of inorganic mercury. Organomercury compounds, especially alkyl mercury compounds, are viewed as posing the greatest toxicological danger [4]. Given their high specific gravity/density values, elemental and inorganic mercury compounds are generally susceptible to gravitational deposition in sediments of aqueous environments. Given the relative values of water solubility and vapor pressure, mercury should be expected to be a fairly mobile material. Mercury entering surface waters can be microbially converted to methylmercuric ion given favorable conditions. Methylmercury accumulates in carnivorous fish to levels 10,000 times those concentrations found in the ambient water [1].

HUMAN TOXICITY

General. Long-term exposure to either organic or inorganic mercury can permanently damage the brain, kidneys, and developing fetuses. Short-term exposure can also have adverse health effects, but full recovery is more likely. Methylmercury is a potent neurotoxin [1]. The USEPA has placed inorganic mercury in weight-of-evidence Group D, indicating that it is not classifiable as to human carcinogenicity [5].

Oral Exposure. The chronic RfD of 0.0003 mg/kg/day is based on kidney effects observed following oral administration in the rat [6]. Oral absorption of metallic mercury by humans has been estimated to be approximately 0.10%. Organic forms of mercury are readily absorbed by humans and animals via the oral route. For example, in one study approximately 95% of methylmercuric nitrate was absorbed. The oral LD_{50} for $HgCl_2$ ranged from 35 to 105 mg/kg in rats. The lethal dose of $HgCl_2$ in adult humans has been estimated to range from 10 to 42 mg/kg. Signs of acute mercury toxicity in humans and animals include gastrointestinal lesions and renal involvement. Death is usually caused by shock, cardiovascular collapse, acute renal failure, and severe gastrointestinal damage. A number of human deaths have resulted from organic mercury ingestion; the lethal dose is estimated to range between 10 and 60 mg/kg. A neurological syndrome in humans following the consumption of methylmercury-contaminated fish has been characterized by many symptoms including tingling in the extremities, incoordination, weakness, slurred speech, irritability, memory loss, depression, insomnia, and impaired vision, hearing, taste, and smell. Pregnant women who have ingested organic mercury have given birth to infants with severe brain

damage. The evidence that the brain damage was caused by organic mercury is very strong [1].

Inhalation Exposure. The RfC of 0.0003 mg/m^3 is based on a NOAEL of 0.009 mg/m^3 determined for humans exposed by inhalation [6]. Metallic mercury diffuses rapidly across lung membranes into the blood. Studies have shown that about 74 to 80% of inhaled elemental mercury vapor is retained in human tissues. Exposure to a metallic mercury vapor concentration of 28.8 mg/m^3 for 1 to 30 hours reportedly caused death in rabbits. In humans, death reportedly occurred following exposure to about 1.1 mg/m^3 diethylmercury vapor for 4 to 5 months. Symptoms of exposure to metallic mercury vapor in humans include chest pains, dyspnea, cough, hemoptysis, impairment of pulmonary function, tremors, insomnia, decreased motor function, headaches, decreased libido, and irritability. Some kidney damage in humans may occur at vapor concentrations of elemental mercury of 0.1 mg/m^3. Inorganic mercury vapor has been reported to cause menstrual disturbances and spontaneous abortions in women, and congenital malformations and resorptions in the offspring of exposed female rats [1].

Dermal Exposure. Both inorganic and organic forms of mercury are absorbed by the skin, although the extent of absorption was not reported. Children exposed dermally to inorganic mercury salts exhibited the following symptoms: tremor of face or extremities, sudden jerky movements, a lack of muscle tone, impaired reflexes, seizures, light sensitivity, deafness, insomnia, and irritability. Symptoms in an adult human exposed dermally to metallic mercury were reported to include headache, tinnitus, and vertigo [1].

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NICKEL

CAS NUMBER

7440-02-0

COMMON SYNONYMS

None.

ANALYTICAL CLASSIFICATION

Inorganic.

PHYSICAL AND CHEMICAL DATA

Water Solubility: Insoluble [1]
Vapor Pressure: Insignificant at 25°C [1]
Henry's Law Constant: Not Applicable
Specific Gravity: 8.90 [2]
Organic Carbon Partition Coefficient: NA [1]

BACKGROUND CONCENTRATIONS

Nickel is a naturally-occurring element. The concentration of nickel in minimally disturbed soils varies tremendously. A collection of 1,318 soil samples from across the conterminous U.S. determined that 81 percent were less than or equal to 20 ppm, with a geometric mean of 13 ppm, but with a maximum value as high as 700 ppm [3]. Levels as high as 24,000 ppm have been found in soils near metal refineries [1].

FATE AND TRANSPORT

Nickel is dispersed throughout the atmosphere primarily as a result of anthropogenic activities. The primary source of nickel in the atmosphere is from the burning of fuel oil. Most of the nickel in the atmosphere occurs in the aerosol form, and is believed to be nickel sulfate. The average residence time for nickel in the atmosphere is 7 days, during which time long-distance transport may occur. Wet or dry deposition is expected to be the primary fate process in air [1].

Nickel is extremely persistent in water. Any nickel found in surface water or groundwater at moderate to high concentrations is probably of anthropogenic origin. In pristine environments, nickel tends to precipitate or be sorbed, leading to decreases in mobility and bioavailability. In polluted waters containing more organic matter, organic materials will keep nickel solubilized by complexation. In water under anaerobic conditions, and in the presence of sulfides, nickel will precipitate out as nickel sulfide.

Nickel is not believed to volatilize from water, or undergo biotransformation by microorganisms in water. Nickel is bioaccumulated by some aquatic plants, but not fish [1].

The average residence time of nickel in soil is estimated to be 2,400 to 3,500 years. Although it is extremely persistent in soil, it can leach to groundwater. Organic complexing agents appear to restrict movement in soil. Nickel may be immobilized in soil as various inorganic complexes. It is not expected to volatilize from soil. It is reasonably mobile in low pH and cation exchange capacity mineral soils, but less mobile in basic mineral soils and soils with high organic content. Acid rain can facilitate leaching. Some terrestrial plants accumulate nickel [1].

HUMAN TOXICITY

General. The primary targets of nickel toxicity are the respiratory, gastrointestinal and immunological systems [1]. Studies in animals suggest that low levels of nickel may be necessary to maintain good health, but this has not been shown in humans [1]. Nickel is considered to be genotoxic. Metallic nickel has not been placed in a weight-of-evidence cancer group by the USEPA, but both nickel refinery dust and nickel subsulfide have been placed in Group A, indicating that they are human carcinogens [1].

Oral Exposure. A chronic oral RfD of 0.02 mg/kg/day is based on a NOAEL of 5 mg/kg/day for decreased body and organ weights in a chronic oral study in rats [4]. Nickel is poorly absorbed following oral exposure [1]. Acute oral LD_{50} values in rodents ranged from 66 to 136 mg Ni/kg [1]. A fatal oral dose in humans of approximately 570 mg Ni/kg has been reported [1]. Information regarding the effects of nickel in humans following oral exposure are limited. Gastrointestinal distress and effects on the blood were noted in workers who drank nickel-contaminated water from a drinking fountain (approximately 7 mg Ni/kg) [1]. Animal studies indicate that oral exposure to nickel (> 0.7 mg Ni/kg/day) can result in adverse effects on the blood, lungs, kidneys, and sperm, and decreases in body and organ weights [1]. There is no evidence that oral exposure to nickel causes developmental effects in humans, but animal studies suggest that nickel may be fetotoxic [1]. Oral exposure to metallic nickel has not been reported to cause cancer in humans or animals, therefore, an oral slope factor is not available [4].

Inhalation Exposure. An inhalation RfC for nickel is currently under review by the USEPA [4]. Approximately 35% of inhaled nickel is absorbed into the blood [1]. Acute inhalation exposure to nickel has not been reported to be fatal in humans, and acute LC_{50} values in animals are not available [1]. The respiratory system is the target of nickel toxicity in people employed in nickel refineries or in nickel processing plants. Respiratory effects reported in occupationally exposed workers include chronic

bronchitis, emphysema, and reduced lung capacity. Of greater concern, however, is the production of cancer of the lung and nasal cavity. Recent studies indicate that cancer usually occurred when the workers were exposed to > 1 mg Ni/m^3 of soluble nickel compounds (such as nickel sulfate or nickel chloride) or to > 10 mg Ni/m^3 of insoluble nickel compounds (such as nickel oxide) [1]. An inhalation Unit Risk for cancer is not available for the soluble salts of nickel, but is available for nickel subsulfide and nickel refinery dust [4]. Inhaled nickel has not been associated with developmental or reproductive effects in humans, but testicular effects have been found in animal studies [1].

Dermal Exposure. Dermal exposure to nickel has not been reported to be fatal in humans or animals [1]. The most prevalent effect of nickel to the general population is the production of skin allergies that result in dermatitis [1]. These allergies can be elicited in sensitive individuals following exposure to nickel via any route [1].

REFERENCES

1. ATSDR, 1991. Toxicological Profile for Nickel (Draft). Agency for Toxic Substances and Disease Registry. USPHS/USEPA. October 1991.
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3. USGS, 1984. Elemental Concentrations in Soils and Other Surficial Materials of the Conterminous United States. United States Geological Survey Professional Paper 1270, U.S. Department of the Interior. United States Government Printing Office, Washington, D.C. 105 pp.
4. USEPA, 1993. Integrated Risk Information system (IRIS). On-line data base. October 5, 1993.

SELENIUM

CAS NUMBER

7782-49-2

COMMON SYNONYMS

Vandex; CI77805; selenium base; selenium dust; colloidal selenium; selenium homopolymer [1].

ANALYTICAL CLASSIFICATION

Metal.

PHYSICAL AND CHEMICAL DATA

Water Solubility: Insoluble [1]
Vapor Pressure: Insignificant at 25°C [1]
Henry's Law Constant: Not Applicable
Specific Gravity: 4.81 at 20°C [2]
Organic Carbon Partition Coefficient: NA

BACKGROUND CONCENTRATIONS

Selenium is a naturally-occurring element. The concentration of selenium in minimally disturbed soils varies tremendously. A collection of 1,267 soil samples from across the conterminous U.S. determined that 80 percent were less than or equal to 0.5 ppm, with a geometric mean of 0.26 ppm, but with a maximum of 5 ppm [3].

FATE AND TRANSPORT

The behavior of selenium in the environment is dependent upon its oxidation state, and the behavior of the chemical compounds formed as a result of the differing oxidation states. In addition, the oxidation state of selenium in the environment is dependent upon a number of environmental factors, including pH, Eh, and biological activity, etc. For releases of selenium to soils, pH and Eh will be the primary determining factors for its fate and transport. Elemental and/or inorganic selenium may undergo microbial methylation (to dimethyl selenide and dimethyl diselenide), ultimately being volatilized to the atmosphere. Temperature, however, will moderate the methylation of selenium; reductions in temperature from 20°C to 4°C resulted in a methylation rate reduction of 90 percent. Acidic soil conditions favor the predominance of selenides. Selenides are insoluble and are expected to be immobile in the soils. Neutral to alkaline soil conditions favor the predominance of selenates. Selenates are expected to be very

mobile in soils, given their high solubility and low sorption potential, and represent a potential for leaching to unprotected groundwaters. For water-soluble selenium compounds (i.e., selenates), terrestrial plant uptake represents a removal/transport mechanism of concern, but will be influenced by a variety of environmental factors (e.g., pH, soil type, reduction oxidation (redox) potentials, etc.) [1].

Selenium released to surface waters is expected to be found in the form of salts of selenic and selenious acids. Salts of selenic acid (such as sodium selenate) are generally found in aerobic, alkaline waters, and are expected to be highly mobile in the aquatic environment. Salts of selenious acid (selenite salts) are found in neutral to acidic waters, and show less environmental mobility than do selenate salts. Under acidic conditions, however, selenite is readily reduced to elemental selenium; selenate, as well, is converted to elemental selenium, but more slowly. Elemental selenium will be stable over a wide range of pH and redox conditions. Aquatic organisms, however, will convert selenium to selenoamino acids and, subsequently, methylated selenium compounds. Neither metabolic product is expected to exist long in the aquatic environment, with the methylated forms volatilizing rapidly to the atmosphere. Selenium in the aquatic environment has been demonstrated to bioaccumulate ($\log_{BAF}$ = 3.60), bioconcentrate ($\log_{BCF}$ = 3.27), and, potentially, biomagnify in aquatic organisms [1].

Atmospheric concentrations of selenium are generally found as inorganic compounds such as selenium dioxide and hydrogen selenide, and organic compounds such as dimethyl selenide and dimethyl diselenide. Dry and/or wet deposition of selenium compounds is expected to account for some removal of these materials from the atmosphere [1].

HUMAN TOXICITY

General. Selenium is considered an essential element. Toxic effects may occur, however, when too much selenium is taken into the body. The major target of selenium toxicity is the lungs, with the heart, liver, and kidneys also being affected. Selenium is considered to be genotoxic [1]. The USEPA placed selenium in weight-of-evidence Group D, indicating that it is not classifiable as to human carcinogenicity [4].

Oral Exposure. A chronic oral RfD of 0.005 mg/kg/day is based on a NOAEL of 0.015 mg/kg/day for clinical selenosis in a human epidemiology study [4]. Selenium is readily absorbed following oral exposure. Acute oral LD_{50} values of 4.8 - 7 mg/kg in rats, 3.2 - 3.5 mg/kg in mice, 2.3 mg/kg in guinea pigs and 1.0 mg/kg in rabbits have been reported for selenium [1]. In humans, selenium exposure has resulted in death, but the fatal dose is not known. Following accidental ingestion of selenium, effects on the lungs

(pulmonary edema, breathing difficulties), upset stomachs and muscular weakness have been noted. The dose resulting in these effects is not known. Symptoms reported in people who ingested selenium over a long period of time include loss of hair, loss of and poorly formed nails, problems with walking, reduced reflexes and some paralysis. These effects occurred at doses greater than or equal to 0.053 mg/kg/day [1]. Selenium has not been found to cause developmental effects in humans or mammals, but birth defects have been found in birds [1]. Most epidemiological studies indicate that selenium is not carcinogenic to humans. In fact, some animal studies suggest that oral selenium may inhibit cancer. An oral slope factor for cancer is not available for selenium [4].

Inhalation Exposure. A chronic inhalation RfC is not available for selenium [4]. Selenium is readily absorbed following inhalation exposure. Acute inhalation LC_{50} values in guinea pigs ranged from 1-12.7 mg/m^3 for 2 to 8 hours [1]. Inhaled selenium has not been reported to be fatal in humans. In both humans and animals, the respiratory system is the primary target of inhaled selenium because selenium is an irritant when it comes in contact with water. Short-term exposure to high concentrations of selenium (exact levels not known) results in pulmonary edema, bronchial spasms, symptoms of asphyxiation, and persistent bronchitis [1]. Neurological effects (headaches, dizziness, malaise) have also been noted following short-term inhalation of selenium. Occupational exposure to low concentrations (0.007-0.05 mg/m^3) has resulted in slight tracheobronchitis [1]. Information regarding the potential effects of inhaled selenium on reproduction and development are not available. Inhaled selenium has not been reported to cause cancer in humans or animals, therefore, an inhalation Unit Risk is not available [4].

Dermal Exposure. Contact dermatitis and skin rashes have been reported following both acute and chronic exposure to selenium [1]. This is due to the irritative properties of selenium. Other information regarding the toxicity of selenium following dermal exposure are not available.

REFERENCES

1. ATSDR, 1989. Toxicological Profile for Selenium. Draft. Agency for Toxic Substances and Disease Registry. USPHS/USEPA. December 1989.
2. Merck, 1989. The Merck Index, Eleventh Edition. Merck & Company, Inc. Rahway, NJ.
3. USGS, 1984. Elemental Concentrations in Soils and Other Surficial Materials of the Conterminous United States. United States Geological Survey Professional

Paper 1270, U.S. Department of the Interior. United States Government Printing Office, Washington, D.C. 105 pp.

4. USEPA, 1993. Integrated Risk Information System (IRIS). On-line data base. October 5, 1993.

SILVER

CAS NUMBER

7440-22-4

COMMON SYNONYMS

Argentum; Argentum crede; CI77820; shell silver; silver atom; silver colloidal; silflake; silber [1].

ANALYTICAL CLASSIFICATION

Metal.

PHYSICAL AND CHEMICAL DATA

Water Solubility: Insoluble [1]
Vapor Pressure: Insignificant at 25°C [1]
Henry's Law Constant: Not Applicable
Specific Gravity: 10.49 at 15/4°C [2]
Organic Carbon Partition Coefficient: NA

BACKGROUND CONCENTRATIONS

Silver is a naturally-occurring element whose average abundance is 0.1 ppm in the earth's crust and 0.3 ppm in soil [1].

FATE AND TRANSPORT

Silver is a white metal with a face-centered cubic structure. With the exception of gold, no other metal is more malleable or ductile. Silver is not appreciably attacked by water, atmospheric oxygen, or most acids (with the exception of dilute nitric acid and hot concentrated sulfuric acid). It is insoluble in water, but solubilizes in fused alkali hydroxides (in the presence of air), in alkali cyanides (in the presence of air), and in fused alkali peroxides. Additionally, most salts of silver are photosensitive [2].

Silver released to soils under oxidizing conditions will be found primarily in compounds with bromide, chloride, and/or iodide; silver released to soils under reducing conditions will be primarily in the form of free silver metal and/or silver sulfide. The fate and transport, then, of silver released to soils is a function of the form of silver-containing material/compound released (i.e., elemental silver versus silver nitrate). In addition, the mobility of silver through soils is influenced by: the drainage rate of the soil (silver is readily removed from well-draining soils); the reduction-oxidation (redox) potential and pH of the soil, which affects the ability of manganese and iron (among

others) to immobilize silver; and organic matter, which tends to form complexes with silver. Plants account for another mechanism of silver removal from soils since plants will take silver from soils into the root system. Biodegradation and/or biotransformation of silver is expected to be very restricted since silver proves toxic to most microorganisms [1].

Silver released to waters will be found primarily as sulfates, bicarbonates, sulfate salts, chlorides, and particulate-associated matter. Sorption appears to be the primary process affecting partitioning of silver through sediment layers in waters, with silver being sorbed readily by compounds such as manganese dioxide. The redox potential and pH of waters will affect the ability of silver to sorb to organic matter therein. Bioconcentration of silver in aquatic organisms represents another fate/transport process of significant concern, given the bioconcentration factor ($\log_{BCF} = 4.82$) for silver. In addition, silver is slowly bioaccumulated by aquatic organisms ($\log_{BAF} = 1.41$). Biomagnification through the trophic levels is expected to be minimal, however. As with silver released to soils, silver released to waters is not expected to undergo significant biodegradation/biotransformation given its inherent toxicity [1].

Atmospheric concentrations of silver will primarily be found as particulate-associated matter and/or fine particles of metallic silver. The major forms of atmospheric silver include: metallic silver, silver sulfide, silver sulfate, silver carbonate, and silver halides. Silver found in any of these forms may be subject to long-range transport, and will eventually be removed from the atmosphere via dry or wet deposition; up to 50 percent of silver released to the atmosphere from industrial operations has been demonstrated to travel up to 100 km prior to deposition [1].

HUMAN TOXICITY

General. The major targets of silver toxicity are the respiratory system following inhalation exposure and the skin following inhalation, oral, and dermal exposure [1]. Data suggest that silver is a mutagen. The USEPA has placed silver in weight-of-evidence Group D, indicating that it is not classifiable as to human carcinogenicity [3].

Oral Exposure. A chronic oral RfD of 0.005 mg/kg/day is based on a LOAEL of 0.014 mg/kg/day for argyria in a long-term study in humans [3]. Approximately 20 percent of an oral dose of silver is absorbed through the gastrointestinal tract [1]. Ingested silver has not been reported to be fatal to humans, and LD_{50} values are not available for animals. Short- and long-term ingestion of silver results in argyria (grey or blue-grey discoloration of the skin) in humans. The dose associated with argyria is not known. Argyria is considered to be more of a cosmetic problem rather than a health problem.

Information is not available regarding the potential effects of silver on reproduction or development in humans. There is no evidence that silver causes cancer in humans or animals and, therefore, an oral slope factor is not available [3].

Inhalation Exposure. A chronic inhalation RfC is not available for silver [3]. Silver is absorbed through the respiratory tract, but the extent of absorption is not known. Inhaled silver has not been reported to be fatal to humans, and LC_{50} values are not available for animals. Occupational exposure to 0.039 to 0.378 mg/m^3 has resulted in effects on the respiratory system (sneezing, stuffiness, runny nose, sore throat, cough, wheezing, chest tightness) and on the gastrointestinal system (abdominal pain) [1]. Occupational exposure also results in argyria. Information is not available regarding the potential effects of silver on reproduction or development in humans. There is no evidence that silver causes cancer in humans or animals, and therefore, an inhalation Unit Risk is not available [3].

Dermal Exposure. Silver has not been reported to be fatal in humans or animals following dermal exposure. Argyria and mild allergic responses are the only known effects of dermal exposure to silver [1]. The doses that elicit these effects are not known.

REFERENCES

1. ATSDR, 1990. Toxicological Profile for Silver. Draft. Agency for Toxic Substances and Disease Registry. USPHS/USEPA. December 1990.
2. Merck, 1989. The Merck Index, Eleventh Edition. Merck & Company, Inc. Rahway, NJ.
3. USEPA, 1993. Integrated Risk Information System (IRIS). On-line data base. October 5, 1993.

ZINC

CAS NUMBER

7440-66-6

COMMON SYNONYMS

None noted.

ANALYTICAL CLASSIFICATION

Inorganic.

PHYSICAL AND CHEMICAL DATA

Water Solubility: Insoluble [1]
Vapor Pressure: Insignificant at 25°C [1]
Henry's Law Constant: Not Applicable
Specific Gravity: 7.14 at 25/4°C [2]
Organic Carbon Partition Coefficient: NA

BACKGROUND CONCENTRATIONS

Zinc is a naturally occurring element essential to many life forms [1]. It is widespread in nature and may be found in many known compounds. The estimated occurrence of zinc in the earth's crust is 0.02 percent by weight [2]. The concentration of zinc in minimally disturbed soils varies tremendously. A collection of 1,248 soils samples from across the conterminous U.S. determined that 87 percent were less than or equal to 74 ppm, with a geometric mean of 48 ppm, but with a maximum as high as 3,500 ppm [3].

FATE AND TRANSPORT

Elemental zinc is a bluish-white, lustrous metal having a distorted hexagonal close-packed structure [2]. It is stable in dry air, but upon exposure to moist air will form a white coating composed of basic carbonate. Zinc loses electrons (oxidizes) in aqueous environments [2]. In the environment, zinc is found primarily in the 2+ oxidation state. Elemental zinc is insoluble; most zinc compounds show negligible solubility as well, with the exception of elements (other than fluoride) from Group VIIa of the Periodic Table compounded with zinc (i.e., Zn Cl_2, ZnI_2) showing a general 4:1 compound to water solubility level. In polluted waters, zinc often complexes with a variety of organic and inorganic ligands. Therefore, the overall mobility of zinc in an aqueous environment, or through moist-to-wet soils, may be accelerated by compounding/complexing reactions [1].

Zinc has a tendency to adsorb to soils and sediment/suspended solids in waters. Adsorption to sediments/suspended solids is the primary fate for zinc in aqueous environments, and will greatly limit the amount of solubilized zinc. Zinc is an essential element and, therefore, is accumulated by all organisms. Zinc concentrations in air are relatively low except near industrial sources. Volatilization is not an important process from soil or water [1].

HUMAN TOXICITY

General. Zinc is an essential trace element, therefore, toxic effects can result if too much or too little is taken into the body. The Recommended Dietary Allowances (RDAs) for zinc are 15 mg/day for men and 12 mg/day for women [1]. The major targets of zinc toxicity are the gastrointestinal tract following oral exposure and the lungs following inhalation exposure [1]. Zinc is not mutagenic and has been placed in weight-of-evidence Group D, indicating that it is not classifiable as to human carcinogenicity by the USEPA [4].

Oral Exposure. A chronic oral RfD of 0.3 mg/kg/day is based on a LOAEL of 2.14 mg/kg/day for anemia in humans [4]. Approximately 20-30 percent of an oral dose of zinc is absorbed by the gastrointestinal tract [1]. Zinc has not been reported to be fatal to humans and oral LD_{50} values in animals are not available [1]. In humans, gastrointestinal effects (vomiting, abdominal cramps, diarrhea) and hematological effects (anemia) have resulted from oral exposure to doses greater than 2 mg zinc/kg/day. Long-term administration of zinc can result in copper deficiency [1]. In animals, effects on the liver and kidneys, as well as the gastrointestinal and hematological systems, have been reported [1]. Studies in animals indicate that exposure to high doses of zinc (200 to 500 mg/kg/day) results in reduced fetal growth and altered concentrations of zinc and copper in both the mother and fetus [1]. There is no evidence that exposure to zinc affects development or reproduction in humans. There is no evidence that zinc causes cancer in humans or animals following oral exposure, therefore, an oral slope factor is not available [4].

Inhalation Exposure. A chronic inhalation RfC is not available for zinc [4]. Zinc is absorbed through the respiratory tract, but the extent of absorption is not known. In humans, death has resulted from exposure to high concentrations (estimated at 97,635 mg/m^3) of zinc-containing smoke [1]. In mice, the reported LCT_{50} (product of lethal concentration and time to kill 50% of the animals) of zinc chloride was 11,800 $mg\text{-}min/m^3$ [1]. Short-term exposure to zinc dust and zinc fumes results in "metal fume fever." This condition is characterized by an acute impairment of pulmonary function. Acute (10-12 minutes) inhalation of 600 mg $zinc/m^3$ as zinc oxide has resulted in nasal passage irritation, cough, chest pain, lung rales, and decreased vital capacity. No

symptoms of metal fume fever were reported following exposure to zinc oxide at 14 mg/m^3 for 8 hours, 45 mg/m^3 for 20 minutes, or occupational exposure to 8-12 mg/m^3 [1]. Information is not available regarding effects on reproduction or development in humans or animals following inhalation exposure. There is no evidence that inhaled zinc causes cancer in humans or animals, therefore, an inhalation Unit Risk is not available [4].

Dermal Exposure. Zinc has not been reported to be fatal in humans or animals following dermal exposure. Topical application of zinc (in the form of zinc oxide or calamine lotion), however, is used to promote healing of burns and wounds [1].

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1. ATSDR, 1989. Toxicological Profile for Zinc. Draft. Agency for Toxic Substances and Disease Registry. USPHS/USEPA. December 1989.
2. Merck, 1989. The Merck Index. Eleventh Edition. Merck & Company, Inc. Rahway, NJ.
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4. USEPA, 1993. Integrated Risk Information System (IRIS). On-line data base. October 5, 1993.

Appendix C

Spill Response Plan

APPENDIX C

SPILL RESPONSE PLAN

INTRODUCTION

Every effort will be made to minimize the potential for spills or releases associated with the proposed field investigations. The risk of spills or release to the environment can be managed through the development and implementation of a site-specific Spill Response Plan. The Spill Response Plan developed will identify the potential for spills or release to the environment and immediate actions that will be taken in response to a spill or release.

POTENTIAL SPILL OR RELEASE CONDITIONS

The greatest potential for spills or releases occurs during subsurface investigations and during the handling of drummed wastes generated by drilling activities. For this reason, the spill response plan lists procedures that must be followed during the proposed subsurface investigation to minimize the potential for releases and to minimize the impact to human health or the environment during an emergency spill or release. In addition, the responsibilities of personnel during a spill or release are summarized.

DRILLING SAFETY PRECAUTIONS

Before any drilling or augering operations are performed, ES will determine from existing utility diagrams and site interviews whether underground installations (i.e., sewers, telephone, water, fuel, electrical lines, process lines, waste transfer lines, or liners) are anticipated in the vicinity of the proposed drilling location(s). All drilling locations must be cleared by Tinker AFB personnel before any activities begin. Drilling will not commence until an excavation permit has been issued by the appropriate Tinker AFB authorities.

Prior to drilling, the locations of all underground installations will be investigated, as described above. In addition, drilling will be performed in a cautious manner, slowly, with frequent checks for obstructions. A metal rod may be pushed into the soil and used to probe for obstructions at each drilling location.

EVACUATION ROUTES AND PROCEDURES

An emergency such as a fire may cut off workers from the normal exit near the support zone. Alternate routes must be established for evacuating victims. Routes

should be marked and kept clear. The following guidelines will aid in establishing safe evacuation routes:

- Place the evacuation routes in the predominantly upwind direction of the exclusion zone.
- Run the evacuation routes through the contamination reduction zone. Even if there is not enough time to process the evacuees through decontamination procedures, there should be a mechanism for accounting for all personnel.
- Consider the accessibility of potential routes. Take into account obstructions such as locked gates, trenches, pits, tanks, drums, or other barriers, and the extra time or equipment needed to maneuver around or through them.
- Develop two or more routes that lead to safe areas and that are separate or remote from each other. Multiple routes are necessary in case one is blocked by a fire, spill, or vapor cloud. These routes must not overlap, because if a common point were obstructed by a fire or other emergency, all intersecting routes would be blocked.
- Make escape routes known to all who go on site.

  Mark evacuation routes with materials such as barricade tape, flagging, or traffic cones. Equally important, mark areas that do not offer safe escape or that should not be used in an emergency, such as low ground, which can fill with gases or vapors, or routes blocked by natural barriers, such as cliffs or streams.
- Consider the mobility constraints of personnel wearing protective clothing and equipment. They will have difficulty crossing even small streams and going up and down banks.

GENERAL EMERGENCY RESPONSE PROCEDURES

Response operations adhere to a established sequence that starts with the notification of trouble and continues through the preparation of personnel and equipment for the next emergency.

Notification

Alert personnel to the emergency. Sound a site alarm to:

- Notify personnel
- Stop work activities if necessary
- Lower background noise in order to speed communication
- Begin emergency procedures.

Notify onsite emergency response personnel about the emergency and include essential information:

- What happened
- Where it happened

- Whom it happened to
- When it happened
- How it happened
- The extent of damage
- What aid is needed.

Size Up

Information about the incident and emergency response capabilities must be evaluated. The following information should be determined, to the extent possible:

- What happened:
  - type of incident
  - cause of incident
  - extent of chemical release and transport
  - extent of damage to structures, equipment, and terrain.
- Casualties:
  - victims (number, location, and condition)
  - treatment required
  - missing personnel.
- What could happen. Consider:
  - types of chemicals on site
  - potential for fire, explosion, and release of hazardous substance
  - location of all personnel onsite relative to hazardous areas
  - potential for danger to offsite population or environment.
- What can be done. Consider:
  - equipment and personnel resources needed for victim rescue and hazard mitigation
  - number of uninjured personnel available for response
  - resources available onsite
  - resources available from outside groups and agencies
  - time for outside resources to reach the site
  - hazards involved in rescue and response.

Rescue and Response Action

Based upon the information available, the type of action required must be decided and the necessary steps implemented. Some actions may be done

concurrently. Nobody should attempt a rescue until backup personnel and evacuation routes have been identified. Rescue actions may include:

- Enforce the buddy system: Allow no one to enter an exclusion zone or hazardous area without a partner. At all times, personnel in the exclusion zone should be in line-of-sight or communications contact with the command post supervisor or designee.
- Survey casualties:
  - locate all victims and assess their condition
  - determine resources needed for stabilization and transport.
- Assess existing and potential hazards to site personnel and to the offsite population. Determine:
  - whether and how to respond
  - the need for evacuation of site personnel and offsite population
  - the resources needed for evacuation and response.
- Allocate resources. Allocate onsite personnel and equipment to rescue and incident response operations.
- Request aid. Contact the required offsite personnel or facilities, such as the ambulance, fire department, and police.
- Control. Bring the hazardous situation under complete or temporary control; use measures to prevent the spread of the emergency.
- Extricate. Remove or assist victims from the area.
- Decontaminate. Use established procedures to decontaminate uninjured personnel in the contamination reduction zone. If the emergency makes this area unsafe, establish a new decontamination area at an appropriate distance. Decontaminate victims before or after stabilization as their medical condition indicates.
- Transport. Take measures to minimize chemical contamination of the transport vehicle and ambulance and hospital personnel. Adequately protect rescuers should decontaminate the victims before transport. If this is not possible, cover the victims with adequate sheeting. Before transportation, determine the level of protection necessary for transport personnel. Provide them with disposable coveralls, disposable gloves, and supplied air, as necessary, for their protection. If appropriate, have response personnel accompany victims to the medical facility to advise on decontamination.
- Evacuate:
  - Move site personnel to a safe distance upwind of the incident.
  - Monitor the incident for significant changes. The hazards may diminish, permitting personnel to reenter the site, or increase and require public evacuation.

- Inform public safety personnel when there is a potential or actual need to evacuate the offsite population. Do not attempt large-scale public evacuation. This is the responsibility of government authorities.

Before normal site activities resume, personnel must be fully prepared and equipped to handle another emergency. The contingency plan should be reviewed and revised according to new site conditions and lessons learned from the emergency response.

EMERGENCY SPILL RESPONSE ACTIONS

In the event that a release occurs during or caused by drilling activities, emergency spill response actions will be initiated. Generally appropriate spill response actions are to stabilize and contain the release to the extent possible with available equipment (shovels or drilling material bags) without endangering field personnel, determining the nature of the release materials, and immediately reporting to the ES field team leader.

Important release or spill information the ES field team leader will request includes:

- Where the release occurred;
- What was released or spilled;
- What caused the release;
- Approximately how much was released;
- What is known about the release materials (for example, the spill or release materials are odoriferous);
- Environmental or human health impacts caused by the release; efforts made to contain the release; and
- An estimate of necessary equipment or personnel that will be required to contain or control the release.

The ES field team leader will be responsible for reporting release or spill information to the base personnel and ES management. Specific responsibilities are described below.

DRUM HANDLING PRACTICES

The wastes generated through site investigations (decontamination fluids, soil cuttings, soiled PPE, etc.) will be appropriately handled prior to disposal. The generated wastes will be placed in properly labelled 55-gallon drums that will be staged to minimize interference with site investigation activities. Drum labels will contain information concerning drum contents, date of collection, generator name, and characterization of waste materials.

Accidents may occur during handling of drums that may result in spillage from the drum or physical injury. To improve the safety of drum handling activities, the following procedures will be followed.

The drums will initially be staged near the point of generation. However drum placement will not interfere with site activities. Following generation and labelling, the drums will be moved to a specially designated area for staging prior to disposal. Prior to handling, drums will be inspected visually to identify contents as described by drum labels and verify drum integrity. Incompatible wastes will be segregated during storage. Adequate aisle space will be maintained between drums. To minimize the potential for accidents, drums will only be handled when necessary. Before moving any drums, the appropriate sequence for moving drums and other containers will be determined. Personnel will be trained in proper lifting and drum moving techniques in order to minimize the potential for injuries. Equipment with sufficient rated load capacity will be selected to handle anticipated loads during drum staging.

EMERGENCY DECONTAMINATION PROCEDURES

If prompt life-saving first aid and medical treatment is required, or some physical catastrophe such as fire or explosion must be avoided, decontamination procedures should be omitted.

In cases of severe physical injury, life-saving care should be instituted immediately without considering decontamination. The outside garments can be removed if they do not cause delays, interfere with treatment, or aggravate the problem. Respirators and back pack assemblies must always be removed. Chemical resistant clothing may be cut away. If the outer contaminated garments cannot be safely removed, the individual should be wrapped in plastic, rubber, or blankets to help prevent contaminating medical personnel and the inside of ambulances. No attempt should be made to wash or rinse the victim at the site unless it is known that the individual has been contaminated with an extremely toxic or corrosive material which could also cause severe injury or loss of life. For minor medical problems or injuries, the normal decontamination procedure should be followed.

If contaminants have been inhaled, treatment can only be performed by qualified medical personnel. If the contaminant is on the skin or in the eyes, immediate measures must be taken to counteract the substance's effect. First aid treatment generally includes flooding the affected area with water. However, for some chemicals, water may cause more severe problems.

If a physical hazard must be avoided, decontamination should be carried out after personnel have found a safe location.

RESPONSIBILITIES

It is the responsibility of the ES field team member at the release or spill location to contain or control the release to the extent possible with materials at hand in a manner that does not endanger field or base personnel. The release or spill will be reported to the ES field team leader as soon as practical, within minutes. ES field team members are also responsible for collecting, to the extent possible, general release information, required by the ES field team leader, as described above.

The ES field team leader is responsible for recording the release or spill information reported by ES field personnel and immediately contacting the Tinker Air Force Base Fire Department, if necessary. The Tinker Air Force Base Fire Department can be reached at telephone number 117. The ES field team leader will also notify the ES Site Health & Safety Officer and the ES Project Manager concerning release conditions. In addition, the ES field team leader will coordinate with the ES Site Health & Safety Officer and will enforce site control and serve as a liaison between field personnel and base personnel.

The ES Site Health & Safety Officer is responsible for implementing emergency procedures and maintaining the telephone numbers of the ambulance, local hospital, poison control center, and fire and police departments. The ES Site Health & Safety Officer will advise ES field personnel, Tinker Air Force Base personnel, and medical personnel of potential exposures and possible consequences, as necessary based on release or spill conditions.

Appendix D

Policy Letters from U.S. Air Force

DEPARTMENT OF THE AIR FORCE

HEADQUARTERS OKLAHOMA CITY AIR LOGISTICS CENTER (AFMC)
TINKER AIR FORCE BASE, OKLAHOMA

FROM: OC-ALC/PKOSS
7858 5th St Suite 1
Tinker AFB OK 73145-9106

09 SEP 1993

SUBJ: Procedures Requesting Emergency Care, F34650-F34650-93-D-0106, Order 5001

TO: Engineering-Science Inc
ATTN: Jay Snow
7800 Shoal Creek Blvd Suite 222 West
Austin TX 78757

1. The following procedures should be used when summoning help in emergency situations:

a. Supervisors should call the Hospital Emergency Room at extension 48223, advise them of the nature of the problem, the location, and Supervisor's extension. A spotter should then be placed in a highly visible area to direct the response team to the patient. It is desirable for the spotter to remain in their location until all responding teams have arrived.

b. The Emergency Room will dispatch an ambulance and notify the Fire Rescue Team of the problem and the location. In Building 3001, they will notify the Occupational Medicine Service (OMS), who will also respond during the day shift. Stickers with Emergency Numbers to attach to telephones can be obtained from the Fire Department.

2. In the past, some supervisors in Building 3001 have phoned directly to the Occupational Medicine Service for an emergency response. This could result in a delayed response and could be of concern in serious emergencies where a combined response is necessary.

GORDON MOHON
Contracting Officer
Directorate of Contracting

DEPARTMENT OF THE AIR FORCE

HEADQUARTERS OKLAHOMA CITY AIR LOGISTICS CENTER (AFMC)
TINKER AIR FORCE BASE, OKLAHOMA

FROM: OC-ALC/PKOSS
7858 5th St Suite 1
Tinker AFB OK 73145-9106

SUBJ: Environmental Briefing, F34650-93-D-0106, Order 5001

TO: Engineering-Science Inc
7800 Shoal Creek Blvd Suite 222W
Austin TX 78757

1. Tinker Air Force Base is committed to providing a safe and healthful work environment to all its military and civilian workers, as well as the surrounding communities. Any work you perform as a contractor on base shall not generate an uncontrolled health hazard and/or pollute the environment on base or the surrounding community.

2. The United States Environmental Protection Agency, the State of Oklahoma local municipalities, and Tinker Air Force Base regulate materials discharged into streams, storm drains, etc, and set guidelines for compliance. Many construction and service industries inadvertently contaminate the environment. Therefore, Environmental Management has briefly outlined some major environmental concerns; however, you as the contractor, are responsible for ensuring environmental compliance in your work area.

a. Any disposal of construction or service related materials through storm drain systems is prohibited. These materials include, but are not limited to concrete slurry, paint, paint related materials, detergents, solvents, rinse water, and hazardous/nonhazardous materials.

b. Any construction or service related material entering the industrial waste collections system is prohibited. Contractual allowances may be made through coordination with the Environmental Management Compliance Division (EMC), Civil Engineering (DE), and Base Contracting (PKO).

c. Any hazardous materials used on base must be approved by EM and have material safety data sheets both at the job-site and on file with EM.

d. No past construction project materials may be brought on Tinker Air Force Base for disposal.

e. Each contractor is responsible for disposing of their work-related waste in accordance with all federal, state, municipal, and Air Force regulations.

f. Should any unlabeled drums, hazardous waste labeled drums, or hazardous materials be found on site, advise your employees to stay away from the materials and notify EMC immediately.

g. This list of environmental concerns is not conclusive. If you have any questions concerning any disposal practices, regulations, etc, please contact EMC.

h. As a general contractor, you must brief any subcontractors you may employ on all environmental requirements.

GORDON MOHON
Contracting Officer
Directorate of Contracting

DEPARTMENT OF THE AIR FORCE

HEADQUARTERS OKLAHOMA CITY AIR LOGISTICS CENTER (AFMC)
TINKER AIR FORCE BASE, OKLAHOMA

FROM: OC-ALC/PKOSS
7858 5th St Suite 1
Tinker AFB OK 73145-9106

09 SEP 1993

SUBJ: Contractor/Vendor Pass and ID Procedures

TO: Engineering-Science Inc
7800 Shoal Creek Blvd Suite 222W
Austin TX 78757

1. The following procedures are to be used by contractors/vendors to obtain passes/ID for their service personnel performing work on Government installations:

a. The prime contractor must submit a request on company letterhead to the Contracting Officer listing contract number, location of work site, start/stop dates, and names of employees and subcontractors needing access to the base. The letter will also specify individuals authorized to sign AFMC Form 496, Request for Identification Credentials. The Contracting Officer will endorse the request, attach copy of contract cover page, and forward to the Security Police Pass and ID Office responsible for entry to the work site.

b. Upon termination of the contract or expiration of the identification passes, the prime contractor must ensure that all base identification passes issued to employees and to subcontractors' employees are returned to the Pass and ID Office, and a letter of certification submitted stating all Base Identification Passes have been turned in or have been accounted for. This certification is attached to the invoice at the time of submittal for payment. Mailing address: OC-ALC/PKOSS, ATTN: Gordon Mohon, 7858 5th St Ste 1, Tinker AFB OK 73145-9106. Noncompliance with these requirements results in withholding of final payment.

2. Any questions may be directed to the Contract Administrator, Gordon Mohon, at the above address or by telephone at 405-739-3367.

GORDON MOHON
Contracting Officer
Directorate of Contracting

DEPARTMENT OF THE AIR FORCE

HEADQUARTERS OKLAHOMA CITY AIR LOGISTICS CENTER (AFMC)
TINKER AIR FORCE BASE, OKLAHOMA

09 SEP 1999

FROM: OC-ALC/PKOSS
7858 5th St Suite 1
Tinker AFB OK 73145-9106

SUBJ: Vertical Clearance Requirement for Contractor and/or Supplier Vehicles

TO: Engineering-Science Inc
7800 Shoal Creek Blvd Suite 222 West
Austin TX 78757

1. All contractors and/or suppliers presently doing business with Tinker Air Force Base are advised of the following:

a. Due to limited vertical clearance at Gate 20 and Gate 1, any vehicle carrying cargo exceeding a total aggregate height of 13 feet 6 inches up to 17 1/2 feet vertical clearance from finished grade will be required to use Gate 2 (Industrial Entrance), which is open from 0600-1800.

b. The Security Police Guards at these gates will turn back trucks requiring state permits and re-route them. This might involve detaining trucks during peak base traffic periods until traffic subsides.

c. During the period Tinker Air Force Base has had these structures in place, each has sustained damage due to trucks carrying oversized loads exceeding state maximum height limits. Therefore, it has become necessary to initiate such actions.

2. Contractors and/or suppliers should direct those vehicles falling under the specified height requirement to use Gate 2, which is the Industrial Entrance.

3. Any questions may be directed to Contract Administrator, Gordon Mohon/PKOSS, telephone 405-739-3367.

GORDON MOHON
Contracting Officer
Directorate of Contracting

DEPARTMENT OF THE AIR FORCE

HEADQUARTERS OKLAHOMA CITY AIR LOGISTICS CENTER (AFMC)
TINKER AIR FORCE BASE, OKLAHOMA

FROM: OC-ALC/PKOSS
7858 5th St Suite 1
Tinker AFB OK 73145-9106

SUBJ: Use of the United States Magistrate's Court

TO: Engineering-Science Inc
7800 Shoal Creek Blvd Suite 222W
Austin TX 78757

1. Tinker Air Force Base uses the U.S. Magistrate's Court in Oklahoma City, Oklahoma for minor offenses committed by civilians, as provided for by Air Force Regulation 110-15.

2. This court system applies to all visitors, base personnel, and contractors.

3. A brief resume of the court and how it works is attached.

GORDON MOHON
Contracting Officer
Directorate of Contracting

1 Atch
Resume of U.S. Magistrate's Court

REFERRAL OF CASES TO THE U.S. MAGISTRATE'S COURT

1. Authority: AFR 110-15, AFR 125-3, 18 U.S.C. Sec 1, 18 U.S.C. Sec 13, and 18 U.S.C. Sec 3401.

2. Purpose: To provide Tinker Air Force Base with the means to prosecute offenses committed by civilian employees, dependents, visitors, contractor employees, and non-federally connected civilians.

3. General Information: The United States Code provides for a Magistrate's Court system, operating under the Federal District Court, to try cases involving petty and minor offenses committed on federal property. A petty offense is a crime for which a maximum penalty of six months imprisonment and a fine of $500.00 may be imposed. A minor offense is a crime which may be punished by a maximum of one year imprisonment and a fine of $1,000.00.

a. The decision as to whether to set up and utilize a Magistrate's Court is in the discretion of the Chief Judge of each Federal Judicial District. Cases arising on Tinker Air Force Base involving civilians could be referred to the U.S. Attorney for indictment and prosecution in the Federal District Court.

b. The Chief Judge, United States District Court for the Western District of Oklahoma, has appointed Gary M Purcell as U.S. Magistrate responsible for handling offenses occurring on Tinker Air Force Base. With the magistrate system having gone into effect on 9 February 1982, there are several alternatives for trial of cases arising within federal jurisdictions. These are:

(1) Referral of petty offenses to the Central Violations Bureau (CVB) in Denver, Colorado.

(2) Referral of minor offenses to the U.S. Magistrate's Court in Oklahoma City, Oklahoma.

(3) Referral of more serious offenses to the local U.S. Attorney for prosecution in Federal District Court in Oklahoma City, Oklahoma.

4. Constraints on Use of System: The Federal Court system may be used for cases arising from violation of any federal statute. Also, under the Assimilative Crimes Act (18 U.S.C. Sec 13), offenses which occur on the portion of the base over which the Air Force has exclusive jurisdiction, and which would be a violation of state law if committed off base, may be assimilated into federal law and tried in the federal system.

5. How the System Will Work:

a. Petty Offenses: When Tinker Air Force Base law enforcement personnel apprehend a civilian for a petty offense, they will issue a DD Form 1805 (violation notice) to the offender. The DD Form 1805 will advise the offender whether he must appear in Magistrate's Court, the date appearance is required, or the amount of fine payable to the CVB by mail (in those cases where forfeiture of collateral is allowed). In cases not requiring a mandatory appearance, the offender may send his copy of the DD Form 1805, along with the amount of the fine, to the CVB, and no further action is required. Or, he may request trial by so noting on the DD Form 1805. In this event, the CVB will set a date for trial, notify all parties, and trial will proceed in a normal manner. If an offender ignores a DD Form 1805, the CVB will send one follow-up letter. If that is also ignored, the CVB will notify the Magistrate, who will issue a bench warrant for the arrest of the offender by the U.S. Marshall.

b. Minor Offenses: All offenses, petty or minor, may be referred directly to the Magistrate's Court by the use of a complaint. The court will issue an order authorizing the Base Staff Judge Advocate to sign and file complaints. Upon the signing and filing of complaint, a summons to appear will be issued to the offender and trial will be scheduled in the usual manner.

c. Serious Offenses: Crimes other than petty or minor offenses will be referred to the U.S. Attorney for indictment and trial in Federal District Court in Oklahoma City, OKlahoma.

6. Facilities: For offenses occurring on Tinker Air Force Base, U.S. Magistrate's Court is held every Thursday at the Federal Courthouse in downtown Oklahoma City.

7. Foreign Nationals Assigned to or Visiting Tinker Air Force Base: In most cases, Foreign Nationals are subject to the same rules as Americans.

DEPARTMENT OF THE AIR FORCE

HEADQUARTERS OKLAHOMA CITY AIR LOGISTICS CENTER (AFMC)
TINKER AIR FORCE BASE, OKLAHOMA

FROM: OC-ALC/PKOSS
7858 5th St Suite 1
Tinker AFB OK 73145-9106

09 SEP 1993

SUBJ: Tinker Air Force Base Parking Rules and Regulations, F34650-93-D-0106, Order 5001

TO: Engineering-Science Inc
7800 Shoal Creek Blvd Suite 222W
Austin TX 78757

1. This is to inform you of vehicle parking rules and regulations at Tinker Air Force Base. If these restrictions are not followed, you or your employees could be ticketed and a loss of base driving privileges could result.

2. There is absolutely no parking on Staff Drive, which is located directly east of Building 3001 in Area C. Any vehicles parking on Staff Drive will be subject to immediate removal (towing) at the owner's expense. Loading and/or unloading of material is not permitted prior to 0800 or between the hours of 1100 and 1300 or 1500 and 1630.

3. Other areas base wide where restrictions apply are as follows:

a. Handicapped slots - No parking at any time.

b. Mission slots - No parking between the hours of 0600-1645 Monday through Friday.

c. Car Pool/Time Limit/Vendor slots - No parking between the hours of 0600-1500 Monday through Friday.

d. Parking in the slots noted in b and c above is permitted outside the hours listed, on weekends, and on holidays.

4. Point of contact is Contract Administrator, Gordon Mohon, telephone (405) 739-3367.

GORDON MOHON
Contracting Officer
Directorate of Contracting

DEPARTMENT OF THE AIR FORCE

HEADQUARTERS OKLAHOMA CITY AIR LOGISTICS CENTER (AFMC)
TINKER AIR FORCE BASE, OKLAHOMA

FROM: OC-ALC/PKOSS
7858 5th St Suite 1
Tinker AFB OK 73145-9106

SUBJ: Clean up of Work Areas and Areas Surrounding Storage/Office Trailers, F34650-93-D-0106, Order 5001

TO: Engineering-Science Inc
7800 Shoal Creek Blvd Suite 222W
Austin TX 78757

1. You are hereby notified that the work area must be cleaned up daily to the satisfaction of the Contracting Officer. All debris and rubbish must be removed daily from the job site and the contractor shall arrange for his own trash pick up. Removal and transportation of debris and unsalvageable materials shall be in a manner as to prevent spillage on streets and adjacent areas. Local regulations regarding hauling and disposal apply.

2. Furthermore, if you are allowed to place storage or office trailers on Tinker Air Force Base, the area immediately surrounding your storage or office trailer will be kept in a neat and orderly manner. This will require the pick up of debris/rubbish and weed/grass control.

GORDON MOHON
Contracting Officer
Directorate of Contracting

DEPARTMENT OF THE AIR FORCE

HEADQUARTERS OKLAHOMA CITY AIR LOGISTICS CENTER (AFMC)
TINKER AIR FORCE BASE, OKLAHOMA

09 SEP 1993

FROM: OC-ALC/PKO SS
7858 5th St Suite 1
Tinker AFB OK 73145-9106

SUBJ: Affirmative Action for Special Disabled and Vietnam Era Veterans, FAR 52.222.35 (Apr 1984), F34650-F34650-93-D-0106, Order 5001

TO: Engineering-Science Inc
ATTN: Jay Snow
7800 Shoal Creek Blvd Suite 222 West
Austin TX 78757

A copy of this letter shall be returned to the undersigned within 2-weeks indicating compliance with FAR Clause 52.222.35.

GORDON MOHON
Contracting Officer
Directorate of Contracting

cc: OK State Employment Security Commission

I certify that we are in compliance with referenced clause for this contract.

Name

9/23/93
Date

DEPARTMENT OF THE AIR FORCE
654 CIVIL ENGINEERING SQUADRON (AFMC)
TINKER AIR FORCE BASE, OKLAHOMA

FROM: 654 CES/CEF

SUBJ: Pre Construction Fire Prevention Briefing for Contractor Personnel

TO: Contractor

1. The contractor or his authorized representative will coordinate all fire requirements/problems through the construction management engineering monitor. All contractors, contractor's employees, and subcontractors must abide by all fire regulations/requirements pertinent to the area they work in or use. It is the prime contractor's responsibility to ensure that any subcontractor is provided with fire requirements/guidelines.

2. Fires during contract maintenance can be prevented or controlled. Danger from fire is usually greater during these operations than after contract completion. Serious fires can occur due to accumulation of flammable combustible materials or debris and the presence of ignition sources. Basic safeguards against construction fire hazards must be provided for during project planning.

3. The following is furnished for your general information and guidance. In no way is this intended to be all inclusive. Contractor operations are of such variable nature this list should be supplemented by the use of applicable safety standards and regulations.

a. Occupational Safety and Health Standards, the National Fire Protection Association, US Army Corps of Engineer Manual EM 385-1-1, Air Force Occupational Safety and Health Standards, Air Force Regulations, and Air Force Technical Orders establish safety procedures which will be followed by all contractor personnel while performing work on an AF installation.

b. The prime contractors will brief their employees and subcontractors on fire reporting procedures. Briefing will include location of administrative and/or fire reporting telephones and fire alarm pull stations in the vicinity of the work site. All fires will be reported to the base fire department (base phones 117/commercial 737-1117).

c. An adequate number and types of portable fire extinguishers will be furnished by the contractor and will be located in plain sight as close to the work as possible. Suitability, distribution, and maintenance of extinguishers will be in accordance with NFPA Standard #10, "Portable Fire Extinguishers".

d. Before any "hot work" (cutting/welding/pipe sweating, etc.) is performed on the job, an AF Form 592, "USAF Welding, Cutting, or Brazing Permit", must be obtained and displayed at the work site for the duration of the permit. Permits can be obtained from the Fire Department by calling 734-7964 or the construction inspector assigned to the job if he is certified by the fire department to issue permits.

e. The work area must be cleaned daily and kept clean and orderly during the period of the contract. All debris and scrap material, tools, and equipment shall be cleaned from the work site as work progresses and upon completion of the job. All combustible-type waste material will be removed from the building or structure at the close of each day. Material will be kept at least 25 feet from any building or structure. Rubbish will not be burned on the site.

f. Do not use any fire hydrants, standpipes, hose or other fire protection equipment except for fire emergencies. For use other than emergencies, i.e., filling trucks, etc., contractors must have approval of the base fire chief.

g. Do not use torches, flares, and flare pots on the flight line, aircraft parking ramps, and POL operations or areas without the approval of the base fire chief.

h. The contractor will notify the base fire department 24 hours in advance when ever an existing fire detection alarm or extinguishing system must be taken out of service, disconnected, relocated, and/or extended. The fire protection system components will be handled carefully to assure reliability when the system is restored to service.

i. Smoking or the use of spark or flame producing equipment in areas where flammable liquids are being used or stored is strictly prohibited.

4. The fire department is available anytime, day or night, for advise and assistance on any matter pertaining to fire prevention/protection by calling 734-7964 (on base 47964).

5. The contents of this letter do not cover and cannot cover all possible fire hazards, but with the cooperation of all parties concerned in the practice of good fire prevention, the possible loss of life and property can be kept to a minimum. Should you have a problem concerning fire protection within your activity, feel free to call us.

James C. Goodbread

JAMES C. GOODBREAD
Chief, Fire Protection Branch

CONTRACTOR'S ACKNOWLEDGMENT

Contractor's Name	Contract Number	Phone Number

I was briefed on the above fire prevention guidelines and rules. I was also advised to brief all of my employees and subcontractors. An additional handout on fire prevention precautions was/was not provided.

Contractor's Signature	Date
	9/9/93

Fire Department Representative

Appendix E

Documentation of Employee Training in Hazardous Waste Operations in accordance with 29CRF Part 1910.120(e)

ENGINEERING-SCIENCE

CERTIFICATE OF TRAINING

This Certifies That

Joe Bauer

Has Successfully Completed a 40 Hour Course of Instruction in

HAZARDOUS WASTE OPERATIONS

Prepared and Conducted By

ENGINEERING-SCIENCE INCORPORATED
Pasadena, California

JANUARY 18-22, 1988
DATES OF INSTRUCTION

Edward Arnold
COORDINATOR/INSTRUCTOR

ENGINEERING-SCIENCE

CERTIFICATE OF TRAINING

This Certifies That

Laura Brock

Employee Number: 455-08-0818

Has Successfully Completed a 40 Hour Course of Instruction in

HAZARDOUS WASTE OPERATIONS

In Accordance with 29CFR Part 1910.120(e)

Prepared and Conducted By

ENGINEERING-SCIENCE, INCORPORATED
Pasadena, California

November 16-20, 1991	Austin, Texas	Timothy S Mustard
Dates of Instruction	Course Location	Coordinator/Instructor

ENGINEERING-SCIENCE

CERTIFICATE OF TRAINING

This Certifies That

Julie Ann Burdey

Employee Number: 389-60-5660

Has Successfully Completed a 40 Hour Course of Instruction in

HAZARDOUS WASTE OPERATIONS

In Accordance with 29CFR Part 1910.120(e)

Prepared and Conducted By

ENGINEERING-SCIENCE, INCORPORATED
Pasadena, California

September 10-14, 1990	Cleveland, Ohio	
Dates of Instruction	Course Location	Coordinator/Instructor

SIRRINE
ENVIRONMENTAL
CONSULTANTS

Certificate Of Training

This Certifies That

MARC W. HARDER

Has Completed A Basic Forty-Hour
Hazardous Waste Site Health And Safety Course
Which Meets The Requirements Of 29 CFR 1910.120 (e)

Presented

MAY 12, 1989

By Sirrine Environmental Consultants, Inc.
Greenville, SC

Edward J. Zilliox
Health And Safety Director

Mark A. McCoy
Instructor

CERTIFICATE OF COMPLETION

GeoResearch
a division of GEOSERVICES,
a California corporation

THIS IS TO CERTIFY THAT

Susan Roberts

WITH GeoResearch
HAS COMPLETED 40 HOURS OF
40 HOUR SARA HAZARDOUS WASTE OPERATIONS TRAINING

GR-0389-12
CERTIFICATE NUMBER

March, 1989
DATE

Ed Bonnet

ENGINEERING-SCIENCE

CERTIFICATE OF TRAINING

This Certifies That

Michelle Lee Town

Employee Number: 456-61-2331

Has Successfully Completed a 40 Hour Course of Instruction in

HAZARDOUS WASTE OPERATIONS

In Accordance with 29CFR Part 1910.120(e)

Prepared and Conducted By

ENGINEERING-SCIENCE, INCORPORATED
Pasadena, California

November 16-20, 1991	Austin, Texas	Timothy S. Mustard
Dates of Instruction	Course Location	Coordinator/Instructor

LAW ENVIRONMENTAL, INC.

This is to certify that

John K. Dill

has successfully completed the 40 hour course

"Health & Safety for Hazardous Waste Operations"

as required by OSHA 29 CFR 1910.120 on

October 7, 1988

Jack Peng, Ph.D., C.I.H.

Jeffrey W. Gold

HAZARDOUS WASTE WORKER COURSE AND WORKSHOP (40-HOURS)

CERTIFICATE

RICKY J. NELSON
Social Security Number: 460-31-2941

This is to certify that the person named above has satisfactorily completed classroom and hands-on training sufficient to satisfy the requirements of 29 CFR 1910.120 for on-site activities at hazardous waste and Superfund sites as mandated under Superfund Amendments and Reauthorization Act of 1986.

November 2, 1989
Certificate Date

40-00092
Certificate Number

November 2, 1990
Expiration Date

Don Kistner
Program Director

RABA-KISTNER TRAINING INSTITUTE, a division of

RABA-KISTNER CONSULTANTS, INC.
12821 W. Golden Lane
San Antonio, Texas 78249
(512) 699-9090

Certificate

May it be known

BY ALL

WHO READ THIS THAT
THIS CERTIFICATE HAS BEEN PRESENTED TO

JOHN OSWEILER

FOR

Successful completion of 40 hours training as required for employee education as specified in SARA 29CFR 1910.120, Section 126E, RCRA 40 CFR 264.16 and OSHA CFR 1910.1200 in Hazardous Materials Communications.

ORGANIZATION Environmental Management

SIGNED Harvey Harper

PRESENTED THIS 11th DAY OF August, 1989

Certificate of Completion

This is to certify that

John Osweiler

has satisfactorily completed

8 Hour Annual Refresher Training in accordance with 29 CFR 1910.120 & 40 CFR 264.16

given by

Fernald Environmental Management Project

Date Completed: March 24, 1993
Expiration Date: March 24, 1994

Technical Staff Training Manager

Certificate of Completion

JOHN OSWEILER

Has Successfully Completed the Course of Instruction in:

8-HOUR HAZWOPER RE-CERTIFICATION

OKLAHOMA SAFETY COUNCIL

GREEN CROSS FOR SAFETY

INSTRUCTOR

APRIL 18, 1994

DATE

Certificate of Achievement

awarded by

EMERGENCY RESPONSE TRAINING CENTER

at

FINDLAY

THE UNIVERSITY OF FINDLAY

to

CRAIG A. PAYNE

For Successful Completion Of

OSHA SITE SUPERVISOR WORKSHOP
(FULFILLS THE REQUIREMENTS OF OSHA 29 CFR 1910.120)
0.8 CEU'S
MAY 7, 1993

J. Robert Van Dyne
Director of Hazardous
Materials Programs

Jan L. Saunder
Instructor

ENGINEERING-SCIENCE, INC.

MEMORANDUM

July 7, 1993

Post-It™ brand fax transmittal memo 7671	# of pages ▸ 1
To Randy Palachek/Tracy King	From Krista Walker
Co.	Co.
Dept.	Phone #
Fax #	Fax #

To: Tim Mustard

From: Kristine Walker KW

Subject: Eight Hour Refresher Training

This letter is to inform you that the following individuals have completed Eight Hour Refresher training in accordance with 29 CFR 1910.120 on June 16, 1993 at the ES-Austin office.

Lea Aurelius
Susan Roberts
Marcus Barksdale
Marc Harder
Srini Dasappa
John Yu
Julie Burdey
Christina Vail
Annette Ponds
Paul Loudermilk (ES-San Antonio)
Ron Flores (ES-San Antonio)
Kevin Tynes
Paul Hunt (based in Houston office)
Lynn Kleinvehn (ES-Houston)

Randy Palachek completed four hours of the required eight hours of refresher training.

A copy of the agenda is attached for your convenience. This letter also serves as certification of completion of the above mentioned training.

If you have any questions or comments, please contact me at (713) 943-5454. Thank you.

cc: Tracy King
Randy Palachek

RUST REMEDIAL SERVICES INC.

CERTIFIES THAT

RANDY PALACHEK
455-84-0196

HAS SUCCESSFULLY COMPLETED THE

8 HR HAZWOPER REFRESHER
29 CFR 1910.120(e)(3)(i)

TRAINING COURSE

Donnie E. Kennedy 10/27/93

INSTRUCTOR

RUST REMEDIAL SERVICES INC.

TERESA ANDERSON
483-56-0718

8 HR HAZWOPER REFRESHER
29CFR 1910.120(e)(3)(i)

Donnie E. Kennedy 10/27/93

RUST REMEDIAL SERVICES INC.

ROBBY CALLEGARI
449-19-8357

8 HR HAZWOPER REFRESHER
29 CFR 1910.120(e)(3)(i)

Donnie E. Kennedy 10/27/93

RUST REMEDIAL SERVICES INC.

LAURA L. BROCK
455-08-0818

8 HR HAZWOPER REFRESHER
29 CFR 1910.120(e)(3)(i)

Donnie E. Kennedy 10/27/93

RUST REMEDIAL SERVICES INC.

MICHELLE TOWN
456-61-2331

8 HR HAZWOPER REFRESHER
29 CFR 1910.120(e)(3)(i)

Donnie E. Kennedy 10/27/93

JOB SAFETY & HEALTH PROTECTION

The Occupational Safety and Health Act of 1970 provides job safety and health protection for workers by promoting safe and healthful working conditions throughout the Nation. Provisions of the Act include the following:

Employers

All employers must furnish to employees employment and a place of employment free from recognized hazards that are causing or are likely to cause death or serious harm to employees. Employers must comply with occupational safety and health standards issued under the Act.

Employees

Employees must comply with all occupational safety and health standards, rules, regulations and orders issued under the Act that apply to their own actions and conduct on the job.

The Occupational Safety and Health Administration (OSHA) of the U.S. Department of Labor has the primary responsibility for administering the Act. OSHA issues occupational safety and health standards, and its Compliance Safety and Health Officers conduct jobsite inspections to help ensure compliance with the Act.

Inspection

The Act requires that a representative of the employer and a representative authorized by the employees be given an opportunity to accompany the OSHA inspector for the purpose of aiding the inspection.

Where there is no authorized employee representative, the OSHA Compliance Officer must consult with a reasonable number of employees concerning safety and health conditions in the workplace.

Complaint

Employees or their representatives have the right to file a complaint with the nearest OSHA office requesting an inspection if they believe unsafe or unhealthful conditions exist in their workplace. OSHA will withhold, on request, names of employees complaining.

The Act provides that employees may not be discharged or discriminated against in any way for filing safety and health complaints or for otherwise exercising their rights under the Act.

Employees who believe they have been discriminated against may file a complaint with their nearest OSHA office within 30 days of the alleged discriminatory action.

Citation

If upon inspection OSHA believes an employer has violated the Act, a citation alleging such violations will be issued to the employer. Each citation will specify a time period within which the alleged violation must be corrected.

The OSHA citation must be prominently displayed at or near the place of alleged violation for three days, or until it is corrected, whichever is later, to warn employees of dangers that may exist there.

Proposed Penalty

The Act provides for mandatory civil penalties against employers of up to $7,000 for each serious violation and for optional penalties of up to $7,000 for each nonserious violation. Penalties of up to $7,000 per day may be proposed for failure to correct violations within the proposed time period and for each day the violation continues beyond the prescribed abatement date. Also, any employer who willfully or repeatedly violates the Act may be assessed penalties of up to $70,000 for each such violation. A minimum penalty of $5,000 may be imposed for each willful violation. A violation of posting requirements can bring a penalty of up to $7,000.

There are also provisions for criminal penalties. Any willful violation resulting in the death of any employee, upon conviction, is punishable by a fine of up to $250,000 (or $500,000 if the employer is a corporation), or by imprisonment for up to six months, or both. A second conviction of an employer doubles the possible term of imprisonment. Falsifying records, reports, or applications is punishable by a fine of $10,000 or up to six months in jail or both.

Voluntary Activity

While providing penalties for violations, the Act also encourages efforts by labor and management, before an OSHA inspection, to reduce workplace hazards voluntarily and to develop and improve safety and health programs in all workplaces and industries. OSHA's Voluntary Protection Programs recognize outstanding efforts of this nature.

OSHA has published Safety and Health Program Management Guidelines to assist employers in establishing or perfecting programs to prevent or control employee exposure to workplace hazards. There are many public and private organizations that can provide information and assistance in this effort, if requested. Also, your local OSHA office can provide considerable help and advice on solving safety and health problems or can refer you to other sources for help such as training.

Consultation

Free assistance in identifying and correcting hazards and in improving safety and health management is available to employers, without citation or penalty, through OSHA-supported programs in each State. These programs are usually administered by the State Labor or Health department or a State university.

Posting Instructions

Employers in States operating OSHA approved State Plans should obtain and post the State's equivalent poster.

Under provisions of Title 29,Code of Federal Regulations, Part 1903.2(a)(1) employers must post this notice (or facsimile) in a conspicuous place where notices to employees are customarily posted.

More Information

Additional information and copies of the Act, specific OSHA safety and health standards, and other applicable regulations may be obtained from your employer or from the nearest OSHA Regional Office in the following locations:

Atlanta, GA	(404) 347-3573
Boston, MA	(617) 565-7164
Chicago, IL	(312) 353-2220
Dallas, TX	(214) 767-4731
Denver, CO	(303) 844-3061
Kansas City, MO	(816) 426-5861
New York, NY	(212) 337-2378
Philadelphia, PA	(215) 596-1201
San Francisco, CA	(415) 744-6670
Seattle,WA	(206) 442-5930

To report suspected fire hazards, imminent danger safety and health hazards in the workplace, or other job safety and health emergencies, such as toxic waste in the workplace, call OSHA's 24-hour hotline: 1-800-321-OSHA.

Lynn Martin

Lynn Martin, Secretary of Labor

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